

3536
GRAHANAMANDANA
OF PARAMESVARA

परमेश्वरविरचितम्
ग्रहणमण्डनम्

Ed. K. V. SARMA

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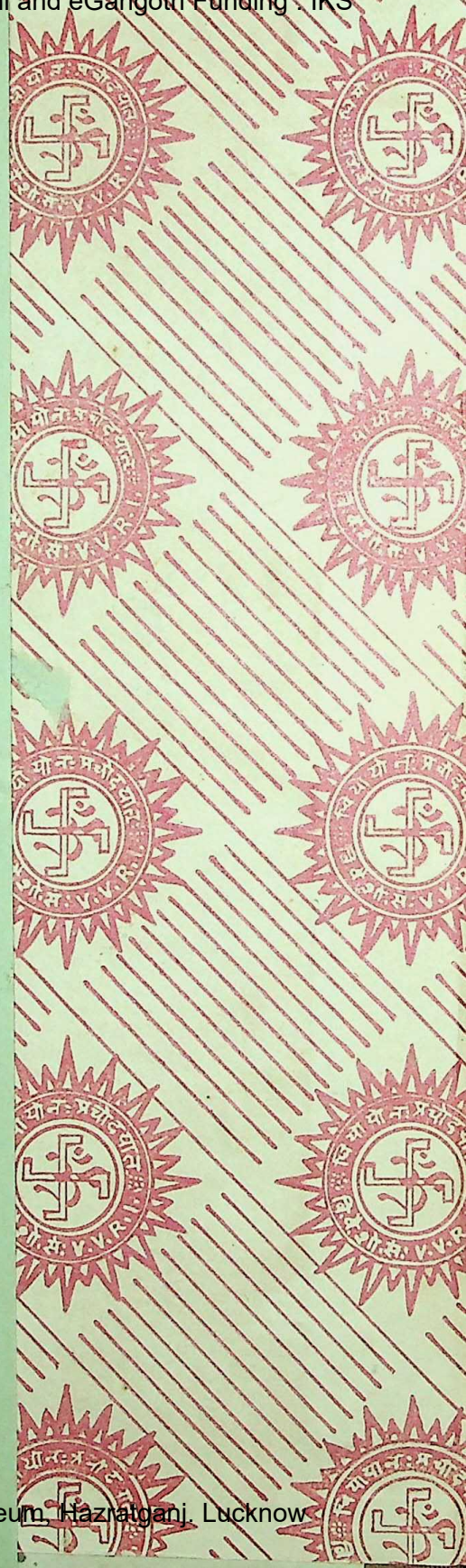
V. V. R. I., HOSHIARPUR

The Grahaṇamaṇḍana offered here in a Critical Edition from original palm-leaf manuscripts with Translation is a product of the researches of an outstanding mediaeval astronomer of India. Para-meśvara (A.D. 1360-1453) who revised the *Parahita* system of astronomy prevalent in Kerala in his *magnum opus*, the **Dr̥ggaṇita**, which he enunciated after careful Investigations extending over 55 years, expounds in the present work methods for the accurate computation of the eclipses of the Sun and the Moon. He gives also methods for the construction of the Eclipse-Graph for the full course of an eclipse and also for the Graph for any moment of the eclipse.

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विश्वेश्वरानन्द-वैदिकशोध-संस्थान-प्रकाशनम्—३६०

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भारते होशियारपुरे, वि. वै. शो. सं. मुद्रागृहे ।

शास्त्रिणा देवदत्तेन संमुद्राप्य प्रकाश्यते ॥

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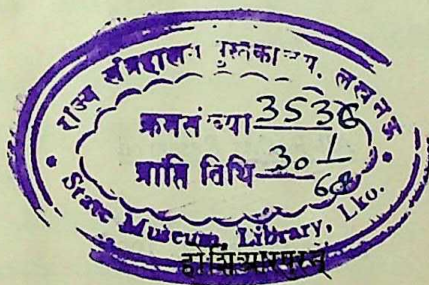
V I. Series-34

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ग्रहणमण्डनम्
THE GRAHANAMANDANA
OF PARAMESVARA

CRITICALLY EDITED WITH A TRANSLATION

By

K. V. SARMA, M.A., B.Sc.



H O S H I A R P U R

विश्वेश्वरानन्द-वैदिक-शोध-संस्थानम्

Vishveshvaranand Vedic Research Institute

सर्वेऽधिकाराः सुरक्षिताः

प्रथमं संस्करणम् , १९६५

प्रकाशकृत्—विश्वेश्वरानन्द-वैदिक-शोध-संस्थानम्
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FOREWORD

The *Grahaṇamaṇḍana* which is now being published as the Volume XXXIV of our *Vishveshvaranand Indological Series*, is an important astronomical work dealing with the accurate computation of the solar and the lunar eclipses. Parameśvara, the author of this work, was an eminent mathematician and astronomer of his day (c. 1360-1455). He lived in Kerala where the *Parahita* system of astronomy was prevalent. By improving upon that system, he ushered in the new *Dr̥k* system of his own. The basic work of this system, namely, the *Dr̥ggaṇita*, which was supposed to have been lost for ever, has been resurrected and already published in 1963 in our above-named *Series* as its Volume XXX.

This edition of *Grahaṇamaṇḍana* is based on six mutually independent palm-leaf manuscripts. The English rendering and the Sanskrit text of the verses are given on opposite pages. It is to be hoped that this arrangement will facilitate the study of this rather abstruse work.

I have pleasure in placing on record my appreciation of the good work done by Shri K. V. Sarma, the learned Editor of this volume in tracing out and securing the relevant manuscripts from the different public and private collections and preparing, on the basis of these, this critical edition which he is now offering along with a translation of the text. He has also prefixed this edition with an informative Introduction.

I am also thankful to our Publication and Printing Departments for the care they have taken in producing this neatly printed and well got-up volume.

VISHVA BANDHU
General Editor

V. V. R. INSTITUTE,
Hoshiarpur,

14th September, 1965.
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INTRODUCTION

The *Grahaṇamaṇḍana* ('Ornament of Eclipses') presented here, in a critical edition, for the first time, is an important work of Parameśvara, the renowned Indian astronomer and mathematician of the 14th-15th century A. D.

Scope of the work

The *Grahaṇamaṇḍana* deals, in a hundred verses, with the accurate computation of the lunar and solar eclipses and their representation on graphs. The text belongs to the *Karaṇa*-type of astronomical works, and, as such, the calculations are commenced in this work from a recent zero date, arrived at by deducting from the current Kali date a large chunk (*Khaṇḍa*) of 16,48,157 Kali days, which corresponds to the Kali year 4512, Kaṭaka 17 or A.D. 1410, July 15 (*śloka* 5). The Mean positions of the Sun, Moon, Higher Apsis (*Pāta*) and Ascending Node (*Tuṅga*), which are required for the computation of eclipses, have been accurately calculated by the author for the above *Khaṇḍa* and given as the zero corrections or Additive Constants (*Dhruva-s*) (*śl.* 9-12) to be applied to their Mean positions as calculated from the zero date (*śl.* 5-8). The further *ślokas* enunciate the different corrections to be applied to the Mean positions and, thus, arrive at their correct positions at the Syzygies (*Parva-s*), the full moon or new moon, as the case may be (*śl.* 13-30). The method to check the possibility of eclipses on the *Parva*-days is also given, since further work might be done only in the case of those *Parva-s* where eclipses are possible (*śl.* 30-31).

The calculation of the orbital diameters of the Sun, Moon and the Earth's Shadow is enunciated next (*śl.* 31-35). The author has, here, an apt simile to illustrate the way in which the solar and lunar eclipses take place :

कुम्भान्तरेण कुम्भो यथा तथा छाद्यते रविः शशिना ।
वारिप्रवेशवत् स्यात् चन्द्रस्य छादनं तमसा ॥ 36 ॥

“(In the solar eclipse) the Sun is hidden by the Moon even as a (spherical) pot by another pot. (In the Lunar eclipse) the hiding of the Moon by the (Earth's) Shadow is like submergence in water.”

The methods for the actual computation of the eclipses of the Moon and the Sun, and the special work applicable only to the Solar eclipse take up the major part of the rest of the work (*śl.* 37-72).

Eclipse-Diagrams

Next is taken up the enunciation of methods to chart eclipses on plane geometrical graphs. Methods are given to convert measures of time into lengths and to construct the Eclipse-Graph using them and other data (§l. 73-87). Methods are given also construct Eclipse-Diagrams to measure off eclipses at any desired moment during their course (§l. 88-94).

Translation

The Translation of the *Grahaṇamāṇḍana* added to the present edition of the work and given alongside the textual verses, on the opposite pages, endeavours, to give a readable rendering of the verses, and also to elucidate the text by providing within brackets the words and ideas omitted from the *śloka*s but are understood from the context.

Scientific outlook of the Author

In the closing verses of the work (§l. 96-99) the author reveals a refreshingly scientific outlook which is remarkable in the case of a mediaeval writer. He has averred in the beginning of the *Grahaṇamāṇḍana* that he was setting out to compose the present work after watching the movements and positions of planets on numerous occasions (cf. *dr̥ṣṭvā golasya saṁsthitiṁ bahuśaḥ*, §l. 3). Then again, in the beginning of his *Dr̥ggaṇita* he has made a similar statement :

“दृश्यन्ते विहगा दृष्ट्या भिन्नाः परहितोदिताः ।
प्रत्यक्षविद्धाः स्युर्ग्रहाः शास्त्रेष्वितीरितम् ॥ I. i. 2 ॥
ये तु शास्त्रविदस्तद्वद् गोलयुक्तिविदश्च तैः ।
स्फुटखेचरविज्ञाने यत्नः कार्यो द्विजैरतः” ॥ 4 ॥
सञ्चिन्त्येति, समालोच्य पूर्वतन्त्राणि यत्नतः ।
स्फुटयुक्तिं खेचराणां गोलदृष्ट्या समीक्ष्य च ॥ 5 ॥
स्फुटखेचरविज्ञानं शिष्यैः प्रार्थितं द्विजैः ।
तेभ्यो दृग्गणितं नाम गणितं क्रियते मया ॥ 6 ॥

Elsewhere he says :

इति विस्तरतः प्रोक्तं ग्रहणं सोमसूर्ययोः ।
दृश्यते तत्र दृग्भेदः काले विभवे कदाचन ॥
तिथिविधौ (1315) समे शाके प्रारभ्य ग्रहणं मया ।
अनेकमीक्षितं तेषु भिन्नः कालो दृशा मया ॥
... ..
उक्तेभ्योऽन्ये चोपरागा मया दृष्टा विवस्वतः ।
इन्द्रोश्च बहवो दृष्टास्ते तु नोदाहृता इह ॥

Mahābhāskariya-Bhāṣya-Vyākhyā (Ed. Madras, 1957) under V. 77

Then again, Nilakanṭha Somayājīn, who had taken his lessons both from Parameśvara and from Dāmodara, son of Parameśvara, and was thus Parameśvara's pupil and grandpupil, speaks of him : परमेश्वराचार्येण पुनः ग्रहणग्रहयोगादिकं यन्त्रैः पञ्चपञ्चाशद्वर्षकालं सन्यक् परीक्षितम् । (Nilakanṭha's *Āryabhaṭīya-Bhāṣya*, under *Gola* 48). Further down, in the same context, Nilakanṭha quotes from Parameśvara :

“ग्रहेन्द्राः पञ्चपञ्चाशद्वर्षकालं निरीक्षिताः ।
मया, तदा दशा भिन्ना दृष्टाः परहितोदिताः ॥
उदाहरणमप्यत्र किञ्चित्तेषां विलिख्यते ।”

Now, this experimenter, thinker and practical astronomer of high calibre pronounces the following judgment on the accuracy of the results arrived at through the computations enunciated by him in his *Grahaṇamaṇḍana*, which is a work of elaborate and painstaking labour :

कालोऽनेन च सिद्धः कदाचिदपि भिद्यते स्वल्पम् ।

“The times (of contact etc.) as obtained from (the calculations enunciated in) this work *may, at times, differ slightly* (from observation).” (*sl.* 96).

He goes on to quote, disapprovingly, Varāhamihira in this matter. Varāhamihira has stated in his *Bṛhatsaṃhitā*, V. 25, that he had given the predictions for the effects of eclipses which occur outside their calculated times only to be in conformity with ancient authors, implying thereby that he does not believe that an eclipse could ever happen like that.¹ The observer and experimenter, *par excellence*, that Parameśvara is, he realises the limitations of Varāhamihira's calculation's, as also of those evolved up to his own time and also by himself, and, so, shrewdly suggests that the small differences observed at times must be due to factors that had not been taken into account or were not known to them. But, as a practical scientist and as one who had been able to enunciate many a correction, he is confident that it would be possible to postulate, as a result of further observation and experimentation, the necessary corrections by the application of which even the small differences found to occur at times could be eliminated. A remarkable statement indeed !

शास्त्रादलब्ध एकः संस्कारो ग्रहणकर्मणि रवीन्द्रोः ।
अस्त्येवेति च कल्प्यः गणकवरैर्युक्तिविन्दिरतः ॥
दृष्ट्वा बहूपरागान् सञ्चिन्त्य च गोलयुक्तिमिह गणकैः ।
कल्प्यः स तु संस्कारस्तस्माद् अथवा गुरूपदेशेन ॥

Grahaṇamaṇḍana, 98-99

1. On this see below, fn. 2 on p. 32.

Correction to the Grahaṇamaṇḍana

The researcher's outlook of Parameśvara and his continuous efforts at bettering his results are evident in his enunciation, in a later work of his, a correction to his *Grahaṇamaṇḍana*. This correction, to be applied to the Mean positions of the Sun, Moon, Apsis and Node, as obtained through calculations according to the *Grahaṇamaṇḍana*, is given at the close of his *Dr̥ggaṇita* with the introductory statement :

कार्यो ग्रहेषु ग्रहणमण्डनोक्तेष्वतः परम् ।
संस्कारस्, तं च वक्ष्यामि तत्र नोक्तं यतो मया ॥ *Dr̥ggaṇita*, II. 47

The verses enunciating this correction have been extracted and translated in an Appendix to the present edition of *Grahaṇamaṇḍana* (see pp. 36-37).

One may sense in our author the researcher's humility and understanding of the limitations of scientific investigations when he assesses, as follows, the worth of the *Dr̥ggaṇita*, his *magnum opus*, perfected, as indicated elsewhere in this Introduction (see pp. xi, xiii), after 55 years of labour :

एवं दृग्गणितं शाके त्रीषुविश्वमिते कृतम् ।
परमादीश्वरेणैतत् “प्रायो” भवति दृक्समम् ॥ *Dr̥ggaṇita* II. 46

Even here, Parameśvara is not prepared to go beyond saying that the results arrived at through his work would accord with actual observation *more or less* (*prāyaḥ*).

Parameśvara, the Author

Parameśvara was a R̥gvedi brāhman of the Āśvalāyana-sūtra and of the Bhṛgu-gotra and was a resident of the village of Ālattūr in South Malabar in Kerala. His house, Vaṭaśśeri, (Sanskritised into Vaṭaśreṇi), by which appellation he was often referred to by later writers,¹ was situated on the northern banks of the river Niḷā or Bhāratappuzha where it joined the Arabian Sea. The author refers to this in several of his works :

निळायाः सौम्यतीरेऽब्धेः कूलस्थः परमेश्वरः ।
संक्षेपाद् गोलसंस्थानं वक्ति बालाय भार्गवः ॥ *Goladīpika* (II), I. 2

At the end of the same work is given the actual location of Parameśvara's village, by its latitude and longitude :

समरेखायाः पश्चादष्टादशयोजनान्तरे ग्रामे ।
स्वरकृतषट् (647) तुलितेऽक्षे वसता ... ॥ *Ib.*, IV. 91²

1. See for instance, Sundararāja's *Vākyakaraṇa-Uvākyā*, (Ed. T. S. Kuppanna Sastri and K.V. Sarma, Madras, 1962), pp. 8, 28, 93.

2. For similar statements, see also the Intro. verses to his Commentary on *Līlavāṭī*, the concluding verse of his Commentary on the *Sūryasiddhānta* etc.

It was, thus, 18 *yojanas* to the west of the Central (Ujjain) meridian and had a Sine latitude of 647, corresponding to $10^{\circ}-51'$, north latitude.¹

Parameśvara does not give more of personal details, but mentions his teacher Rudra in several of his works. Nilakaṇṭha Somayājīn refers to two more of Parameśvara's teachers, viz., Nārāyaṇa and Mādhava :

परमेश्वरस्तु रुद्र-परमेश्वरात्मजनारायण-माधवादिभ्यो गोलविद्भ्यो गणितगोलयुक्तीरपि
वात्य एव सम्यग् गृहीत्वा तेभ्य एव क्रियमाणप्रयोगस्य दृग्विस्वार्दं तत्कारणं चावधार्य शास्त्रार्थपि
बहून्यालोच्य पञ्चपञ्चाशद्वर्षकालं निरीक्ष्य ग्रहणग्रहयोगादिषु परीक्ष्य सम-दृग्गणितं करणं चकार ।

(Nilakaṇṭha's *Āryabhaṭīya-Bhāṣya*, Gola. 48, Edn. Trivandrum Skt. Ser., No. 185, p. 154).

Of these two teachers, Nārāyaṇa could not be identified, but Mādhava has been identified with the reputed astronomer Mādhava, surnamed *Golavid*, (A.D. 1340-1425), belonging to the Saṅgamagrāma (Iriñjālakkuṭa in Cochin, Kerala) and author of an interesting astronomical manual entitled *Veṅvāroha*.² Parameśvara's grandfather too seems to have been an astronomer of repute and was a pupil of Govinda, author of *Muhūrtaratna*. Parameśvara gives this information in his commentary on the *Muhūrtaratna* :

गोविन्दपूज्यपादेन कृपासंसिक्तचेतसा
मुहूर्तागमदुग्धाब्धेर्मुहूर्तमणिरुद्धतः ।
तस्मिन्तच्छिष्यपौत्रेण कियांश्चित् परमादिना
भावोऽवत्रियते स्वल्पम् ईश्वरेण यथाश्रुतम् ॥

Date of Parameśvara

In at least two of his works, Parameśvara gives the date of their composition. His *Dṛggaṇita* was composed in Śaka 1353, corresponding to A. D. 1431.³ He wrote his *Goladīpikā* (II) in Śaka 1365 (A. D. 1443)⁴ Nilakaṇṭha Somayājīn speaks of an astronomical observation by Parameśvara

1. This is referred to in some of his other works as well. See *Grahaṇamanādana*, 14-15; *Laghubhāskariya-Vyākhyā* under I. 33 (*Anandasrama Skt. Ser. No. 128*, p. 12).

2. Ed. K.V. Sarma, Sanskrit College, Trippunithura, (Cochin), 1957, *Ravi Varma Granthāvali*, No. 6. On Mādhava, see Intro. to this edition.

3. Cf. एवं दृग्गणितं शाके 'त्रीषुविश्व' (1353) मिते कृतम् ।

Dṛggaṇita, II. 46

4. Cf. शाकेऽक्षय्यत्रिचन्द्र (1365) मिते ॥

परमेश्वरनाम्नेयं गोलदीपिका रचिता ।

Goladīpikā (II), IV. 91-92

in Kali 4536 (A. D. 1445).¹ The long period of 55 years which Parameśvara spent in celestial observations and calculations before he codified his results through his *Dṛggaṇita* in A. D. 1431 would mean that he should have commenced his studies by about 1375. Presuming that he was not more than a boy then, his date of birth may be put around A. D. 1360.

An idea of the last years of Parameśvara is given by Nilakanṭha (born A. D. 1442),² who speaks of the former having been his teacher.³ Even supposing Nilakanṭha to have sat at the feet of Parameśvara at an young age, it must be around 1455. The above considerations would place Parameśvara between A.D. 1360 and 1455.

Works of Parameśvara

Parameśvara was a prolific writer, author of original works and commentaries covering all fields of Jyotiṣa. Several of his works are yet to appear in print. His works on astronomy are :

1. *Dṛggaṇita*, the author's *magnum opus*, a *Karaṇa* text, in two versions. Considered, to be lost for ever, but resurrected and edited recently through the *Vishveshvaranand Indological Series*, No. 30. (Ed. K. V. Sarma, Hoshiarpur, 1963).

2. *Goladīpikā* (I), on spherical geometry and astronomy. (Ed. T. Ganapati Sastri, Trivandrum, 1916, *Trivandrum Skt. Series*, No. 49).

3. *Goladīpikā* (II), in four chapters, on the same subject as above, but different from it, hardly 10 verses being common between the two. (Ed. and Trans. K. V. Sarma, Adyar Library, Madras, 1957).

1. Cf. भार्गवपरमेश्वरेण अस्मत्परमगुरुणा 'चलांशस्त्वम्' (4536) इति कल्यब्दे पञ्चदशांशपूर्तिनिष्णीता ।

(Nilakanṭha's commentary on his own *Siddhantadarpaṇa*, Ms. No 975 of the Palace Library, Trivandrum, now deposited in the Kerala University Or. Mss. Library, Trivandrum. See the writer's paper, 'Gārgya Kerala Nilakanṭha Somayājīn', *Journal of Or. Res* 26 (1956-57) 37.

2. Cf. The date of his birth is given by him in his commentary on his *Siddhantadarpaṇa* (*op. cit.*) :

स्वजन्मकालज्ञापनाय चैवमुक्तम् । तदा अहर्गणश्च 'त्यजाम्यज्ञतां तर्कैः' इति ।

This Kali date, viz., 16,60 181, works out to December, 1442.

3. In his *Aryabhaṭīya-Bhāṣya*, *Golapāda*, Nilakanṭha quotes Parameśvara's *Goladīpikā* (II), III. 35 with the prefatory statement :

अत एवोक्तमस्मदाचार्येण गोलदीपिकायाम्—

(*Trivandrum Skt. Ser.*, No. 185, p. 27)

4. *Grahaṇamaṇḍana*, on the computation of eclipses. (Ed. and Trans. K. V. Sarma, Hoshiarpur, 1965, *Vishveshvaranand Indological Series*, No. 34).

5. *Grahaṇa-Nyāyadīpikā*, on eclipses. (Unpublished. Mss. : Kerala Univ. Or. Mss. Lib. (KUOML), incomplete and unidentified in the miscellaneous folios towards the end of Ms. No. 762; another Ms. with the present editor.)

6. *Grahaṇāṣṭaka*, on eclipses, in 10 verses. (Ed. and Trans. K. V. Sarma, K. S. R. Institute, Madras-4, in their *J of Or. Res.*, 28 (1958-59) 47-60).

7. *Vākyakaraṇa*, on the methods for the derivation of the several astronomical tables. (Unpublished. Ms. KUOML C. 133-A).

Several of the standard works on astronomy and mathematics which were popular in Kerala have been commented upon by our author :

8. *Bhaṭṭadīpikā*, on the *Āryabhaṭīya* of Āryabhaṭa. (Ed. H. Kern, Leiden, 1874).

9. *Pārameśvara* on the *Laghubhāskariya* of Bhāskara (I). (Ed. *Anandasrama Skt. Series*, No. 128, Poona, 1946).¹

10. *Karmadīpikā* on the *Mahābhāskariya* of Bhāskara (I). (Ed. *Anandasrama Skt. Series*, No. 126, Poona, 1945).

11. *Siddhāntadīpikā* on Govindasvāmin's *Mahābhāskarīya-Bhāṣya*. (Ed. T. S. Kuppanna Sastri, *Madras Govt. Or. Series*, No. 130, Madras, 1957).

12. *Pārameśvara* on the *Laghumānasa* of Muñjāla. (Ed. *Anandasrama Skt. Series*, No. 123, Poona, 1944).

13. *Vivaraṇa*, on the *Sūryasiddhānta* (Unpublished. Mss. : VVRI 2096 ; KUOML 8358-J; Govt. Or. Mss. Lib , Madras, R 3730).

14. *Vivaraṇa*, on the *Līlāvati* of Bhāskara (II). (Unpublished. Mss. : KUOML 10614-B; Madras, ib., R. Nos. 338, 5160, 13003; Adyar 68524).

15. *Vṛtti*, in verse, on an anonymous *Vaytīpātāṣṭaka*, a work on the calculation of the astronomical phenomena called *Lāṭa* and *Vaidhṛta*. (Unpublished. Ms. KUOML 788-D).

1. It has now been ascertained that the unidentified work called *Pārameśvarī* mentioned by me in the Introduction, p. xv, of the edition of the *Dṛggaṇita* is only this work.

16. *Vṛtti* on his own *Goladīpikā* (II). (Ed. K.V. Sarma, Adyar Library, Madras, 1957).

Primarily an author of astronomical works, Parameśvara has written also on astrology. His works in this field are :

17. *Ācārasaṅgraha*, a popular work, of which many Mss. are known in the KUOML and other South Indian collections.

18. *Jātakapaddhati*, on horoscopy. (Ed. Kolatheri Sankara Menon, Trivandrum, *Vaṅci Setu Lakṣmī Granthāvali*, No. 2 ; Ptd. also as Appendices under the headings *Balapiṇḍa* and *Āyurdāya* in the editions of *Jātakādeśa* by Kāṇippayyūr Śaṅkaran Nampūtirippād, Kunnamkulam, M.E. 1102, and by V. N. Śaṅkuṇṇi Nāyar, Kunnamkulam, M.E. 1105).

19. Commentary on the *Muhūrtaratna* of Govinda. (Not published. Ms. KUOML T. 144).

20. Commentary on the *Jātakādeśa* of Śrīpati. (Not published. Ms. KUOML CM. 665).

21. Commentary on the *Praśnaṣatpañcāśikā* of Pṛthuyāśas. (Not published. Mss. : KUOML 5963, 12235, T. 612; Madras, *ib.*, D. 13964).

22-24. *Muhūrtāṣṭaka-dīpikā*, *Vākya dīpikā* and *Bhā dīpikā*, which Parameśvara mentions along with some other works of his at the end of his commentary on the *Mahābhāskariya* are yet to be recovered

Manuscript Material

The present edition of *Grahaṇamaṇḍana* is based on five mutually independent palm-leaf manuscripts, all in the Malayalam script.

- A. Ms. No. C. 166-D of the Kerala University Oriental Mss. Library, Trivandrum. Procured from Sri Subrahmanyam Mūttatu, Harippād, it belonged originally to the family of Kaypañceri Tamprakkal, one of the spiritual heads of the Nampūtiri brāhmins of Kerala, as indicated by an inscription on one of the folios : *itu Kaypañceri Tamprakkal-ute grantham*. It is transcribed in T. 179-A of the KUOML and described in the *Descriptive Cata. of Skt. Mss. in the Curator's Office Library, Trivandrum*, vol. IV, pp. 1333-35. The Ms. is not dated but is much worn out and looks old. The codex contains a number of astronomical texts, all written in a uniform and minute but generally accurate hand by a scribe named Nilakanṭha who writes as follows at the close of one of the works, viz. the *Pāṭigaṇitasāra* :

नीलकण्ठेन लिखितमिदं पुस्तकम् , आर्यभटादि-गणितसाराख्यमखिलम् । आर्यभट्टम् ,
महाभास्करीयम् , सूर्यसिद्धान्तम् , मण्डनम् , अष्टकम् , लीलावती , भास्करीयम् , मानसम् ,
प्रयोगरचना , त्रिशती च एतत्सर्वं नीलकण्ठेन लिखितम् ।

- B. Ms. No. 339-D preserved in the private collection of the Vayaskara Illam, one of the eight principal hereditary Nampūtiri physician-families renowned as the *Aṣṭa-vaidyas* of Kerala. This codex also contains several astronomical tracts. It is undated but old and worm-eaten. The text preserved is generally free from errors.
- C. Ms. No. L. 1248-F of the KUOML. This codex too contains a large number of astronomical texts, several of these being works of Parameśvara. The Ms. is not dated, but is old and the leaves have grown brittle by age. The writing is legible and is generally correct.
- D. Ms. No. 788-B of the KUOML. Again a codex containing several works of Parameśvara. The Ms. is comparatively well preserved and accurate. It belongs to the 89-*śloka* version of the work.
- E. A manuscript presented to the editor by the late M. S. Srinivasa Sastri, eminent astrologer, Palghat ; it belonged originally to the wellknown Nampūtiri family of Kūṭallūr, S. Malabar, Kerala. Well preserved and generally accurate, the Ms. represents the 89-*śloka* version of the work. The codex contains four other works of Parameśvara.
- F. Ms. No. CM. 333-C of the Curator's Office Collection (Malayalam Section) of the KUOML. The Ms. is old and much injured and belongs to the 89-*śloka* version of the work. The collation sheets of this Ms. were received after the text had been printed off. The variants from this Ms. are, therefore, given separately at the end of this edition.

The Two Versions of Grahanaṃaṇḍana

The *Grahanaṃaṇḍana* exists in two versions, one of 89 *ślokas* and the other of 100 *ślokas*, (actually of 91 and 102 *ślokas*, respectively, when the introductory and concluding verses are also taken into account). The first version concludes with the *śloka* :

परमेश्वरेण रचितं नवाधिकाशीति (89) सम्मितार्याभिः ।
एतद्विलसतु सुचिरं गणकानां ग्रहणमण्डनं हृदये ॥

and the second with the same *śloka* slightly altered to suit the metre when the number 89 is substituted by 100 :

परमेश्वरेण रचितं द्विजेन शत (100) सम्मितामिरार्याभिः ।
एतद्विलसतु सुचिरं गणकानां ग्रहणमण्डनं हृदये ॥

The versions have distinct, though minor, differences in the readings of the *ślokas* but the the main difference lies in the occurrence, in the larger

version, of eleven additional verses, nos. 88-94, which enunciate a method for the construction of the Eclipse-Graph for any desired moment, and nos. 96-99 which voice the author's call to astronomers to postulate further corrections to enable eclipses as computed conform exactly with observation.

These additional *ślokas*, it may be noted, do not introduce much by way of new material. The 100-*śloka* version is generally better in the matter of readings, but does not betray any extraneous hand, as can be judged from the style, diction etc. of the *ślokas*. It seems that the work had only 89 *ślokas* when it was first composed and that, at a later date, the author himself effected a few revisions and added the 11 *ślokas* in question. The verbal change in the concluding *śloka* should also have been made then. It may be observed, in this connection, that there is nothing incongruent with this view, for we see something similar elsewhere too in the author's works. For instance, he has two versions of his *Dṛggaṇita*, one giving the figures according to the *Bhūta-saṅkhyā* notation and the other in the *Kaṭapayādi* notation. Similarly, he has two *Goladīpikā-s* (see above, p. xiv). In the same manner, he has three works on eclipses, the *Grahaṇāṣṭaka*, the *Grahaṇamaṇḍana* and the *Grahaṇa-nyāyadīpikā* which have, naturally, something in common.

Acknowledgement

In the present edition and translation of the *Grahaṇamaṇḍana*, I have received much help and advice from Prof. T. S. Kuppanna Sastri, lately of the Presidency College, Madras. I take this occasion to express my sense of indebtedness to him in this matter. To Dr. K. Raghavan Pillai, Curator of the Kerala University Mss. Library, Trivandrum, I am thankful for allowing the use of some of the manuscripts in the Library's collection and, particularly, for arranging for the collation of one of the Mss. (F) used for the edition of the work. Thanks are due also to Brahmasri N. S. Moose of the Vayaskara Illam, Kottayam, and to the late Sri M. S. Srinivasa Sastri of Palghat for graciously making available their manuscripts for use in this edition.

K. V. SARMA

V. V. RESEARCH INSTITUTE,
Hoshiarpur,
Janmāṣṭamī,
August 19, 1965.

ORNAMENT OF ECLIPSES

Composed by

PARAMEŚVARA

(Invocation)

1. Victory to the Lord of the Day, the Awakener of the universe, by coming into contact with whose rays the Moon, Venus, the stars etc. are seen illuminated.

(Introduction)

2. Just as the reflection of one's face can be seen clearly in a mirror, the eclipses of the Sun and the Moon can be seen on the sphere.

3. Having learnt the *Laghutantra* and having observed on numerous occasions the positions of (the planets etc. in the celestial) sphere, the *Ornament of Eclipses* is being composed by me to be a delight to astronomers.

4. Since (the longitude etc.) of the Moon obtained through the *Parahita*¹ and other systems (of astronomy) do not tally (with observed values) in eclipses, I set forth, here, the derivation of the Moon etc. (using methods parallel to those) enunciated by some of the earlier teachers.

(Derivation of Mean Positions)

5. From (the *Khaṇḍa* obtained by) reducing the current Kali day by 16,48,157² the Sun's Mean position is got by multiplying it by 58 and dividing (the product) by 21,185.

1. A system of astronomical computation prevalent in Kerala and which Parameśvara revised in his *Dṛggaṇita*. For the basic text of this shool see *Grahacāranibandhanam* of Haridatta, Ed. K.V. Sarma, K.S.R. Institute, Madras-4, 1954.

2. This *khaṇḍa* corresponds to Kali 4512, Kaṭaka 17 or A. D. July 15, 1410.

परमेश्वरविरचितम्

ग्रहणमण्डनम्

[मङ्गलाचरणम्]

जयति जगतो दिनेशः प्रबोधकृद् यस्य भानुसम्पर्कात् ।
शशिभृगुजतारकाद्या ज्योतिर्दिताः प्रदृश्यन्ते ॥ १ ॥

[ग्रन्थावतारः]

आत्मीयवदनविम्बं प्रदृश्यते दर्पणे यथा व्यक्तम् ।
तद्वद् गोले ग्रहणं प्रदृश्यते चण्डभानुशीतांश्वोः ॥ २ ॥

विज्ञाय च लघुतन्त्रं दृष्ट्वा गोलस्य संस्थितिं बहुशः ।
गणकानां सन्तोषप्रदं मया ग्रहणमण्डनं क्रियते ॥ ३ ॥

यस्मादिन्दुर्ग्रहणे न संवदति परहितादिसिद्धोऽतः ।
इन्द्रादेरानयनं पूर्वं कैश्चित्प्रदर्शितं वक्ष्ये ॥ ४ ॥

[मध्यमानयनम्]

16,48,157

स्वरतिथिभुजङ्गसागरपङ्क्तिविभुभिर्विरहितात् कलेर्युगणात् ।

58

21,185

वसुवाणम्राद् भानोः शरवसुरुद्राश्विभिर्भवति मध्यम् ॥ ५ ॥

śl. 2. pāda-s^{ab}) A. विम्बाः प्रदृश्यन्ते. b) A.B.C. °णेषु for °णे.

3. a) A. om. च. D.E. read after śl. 3 the following two ślokas ; in D, the second śloka is enclosed by brackets, indicating its deletion :

परगुणसन्तप्तानां मानसकुसुमस्य (E. °कुमुदस्य) भानुविम्बस्य ।

स्थूलमपीदं विद्याज् जयन्तमालिकातु सूक्ष्मतरम् ॥

सूक्ष्मोपरागगणना प्रदर्शितं सोपपत्तिकं पूर्वम् ।

लघुभास्करीयविवृतावधिकारसूत्रबुद्धिमतः ॥

4. a) A.C.D.E. °दिन्दुग्रहणे.

5. a) A. भुजग for भुजङ्ग. b) A. कलेरब्दात् (corrupt). d) B. भवन्ति (corrupt).

6a. The Moon's Mean position is got by multiplying (the *Khaṇḍa*) by 143 and dividing by 3907.

6b. That of the Higher Apsis of the Moon is got by multiplying (the *Khaṇḍa*) by 4 and dividing (the product) by 12,931.

7a. The Ascending Node of the Moon is got by multiplying the *Khaṇḍa* by 3 and dividing (the product) by 20,378.¹

7b-8a. Divide the (elapsed) revolutions of the Sun by 283 for the Sun, of the Moon by 52, of the Higher Apsis by 11 and of the Ascending Node by 62. These are minutes.

8b. This is to be subtracted in the case of the Sun and (12°-Node), and to be added in the case of the Higher Apsis and the Moon.

(Additive Constants)

9. The additive constant for the Sun is 3°-18'-15'-7", correct to the seconds. For the Moon, it is 2°-0'-17'-1", correct to the seconds.

10. • For the Higher Apsis of the Moon, it is 2°-5'-23'-18" ; and, for the Node it is 11°-1'-41'-4", correct to the seconds.

1. These multipliers and divisors (*gunakāras* and *harakas*) are the simplified forms of what is given by the author in his *Dr̥ggaṇita*, I. i. 10-11, 20-22. (See *Dr̥ggaṇita*, of Parameśvara Ed. K.V. Sarma, *Viśveśvāranand Indological Series*, No. 30, pp. 3-5).

143 3907
 गुणमनुगुणितादिन्दोर्मध्यं स्यात् सप्तशून्यनवदहनैः ।
 4 12,931
 उच्चं चन्द्रमसः स्याद् वेदघ्नाद् भूमिरामनवसूर्यैः ॥ ६ ॥

3 20,378
 चन्द्रमसः पातस्तु त्रिघ्नाद् वसुपर्वताग्निशून्ययमैः ।
 283 52
 रविभगणादथ भानोऽगुणवसुयमलैः, विधोस्तु यमबाणैः ॥ ७ ॥

11 62
 तुङ्गस्य क्षितिचन्द्रैः शशिपातस्याक्षिषड्भिरपि लिप्ताः ।
 रविचक्रशुद्धराहोः शोध्यास्ता,स्तुङ्गचन्द्रयोः क्षेप्याः ॥ ८ ॥

[ध्रुवाणि]

3r-18°-15'-7"
 शैलास्तिथयोऽष्टादशदहना भानोर्ध्रुवस्य विकलाद्याः ।
 2r-0°-17'-1"
 भूमिर्भूधरचन्द्राः गगनं नेत्रे विधोर्विलिप्ताद्याः ॥ ९ ॥

2r-5°-23'-18"
 भुजगेन्दवो गुणयमाः स्मरवाणा द्वे शशाङ्कतुङ्गस्य ।
 11r-1°-41'-4"
 विकलाद्या जलनिधयो भूवेदा भूः शिवाश्च पातस्य ॥ १० ॥

6. ^{a)} B. गुणितादि broken away. ^{c)} B. उच्चं चन्द्रम broken away.
7. ^{a)} E. पातं तु. ^{b)} E. अहि for वसु. C has after *b* an extra śloka :
 भयु (?) शेषे दिवसे शैलगुणैः स्वाशिशैश्च (?) हरयेदेतान् ।
 खागैस्तवैर्विघ्ना विकलाद्यास्ताः परान्तमिताः ॥
^{d)} B. यमलैः broken off. E. रसशैलैः for यमबाणैः.
8. E. reads the śloka with some variation :
 तुङ्गस्य तु रसवेदैः पातस्याद्रिद्विभूमिभिलिप्ताः ।
 भानोः शोध्याः क्षेप्या विधूचयोश्चक्रशुद्धपाते च ॥
9. ^{a)} E. °यो धृतयो for °योऽष्टादश. ^{c)} E. रुद्रा for चन्द्रा. ^{d)} B. गगनाम्बरनेत्रे.
 B. विधोः broken off.
10. E reads the śloka with different values :
 दसाब्धयो विधुयमाश्चत्वारो द्वे (2r-4°-21'-42") शशाङ्कतुङ्गस्य ।
 विकलाद्या नवरामा द्वे द्वे रुद्राः (11r-2°-2'-39") शशाङ्गपातस्य ॥
^{b)} B. स्मरवा and द्वे broken off. ^{d)} A. पात स्यात् (corrupt).

11. The additive constant is to be added to the Mean position (in the first three cases) and in the case of the Node to (12^r-Node). The planets (i.e., Sun etc.) are to be derived in the above-said manner by those who want, in the computation of eclipses, conformity of observation with calculation.

12. Some say that there is difference on observation (from the results derived by calculation) in the case of the Node, the Higher Apsis and the Moon, others (speak of it) in the case of the Moon, and still others, in the case of the Moon and the Node. We now consider (our above-mentioned) view (of additive constants as given in §. 9-10) as correct.

(Correction for Terrestrial Longitude)

13a. A correction for difference (in longitude) of place has to be applied to the Mean positions. This, I shall state next.

13b-14a. Multiply the (Mean) daily motion in minutes by the difference in *yojanas* (of the place, for which the eclipse is calculated, from the Ujjain or Central Meridian) and divide by the circumference of the Earth at that place. The (resulting) minutes are to be added (if the place is) west of the Central Meridian, and subtracted if east;

14b-15. The Central Meridian is east by 18 *yojanas* from the village of Aśvattha.¹ At this place, the circumference of the Earth is equal to 3240 *yojanas*. The length of the Equinoctical Shadow at this place has been stated by ancient (astronomer) experts by means of the letters *duṣ-ṭā-strī* (which is 2 *angulas* and 18 *vyangulas*).

(Correction for the Equation of the Centre)

16a. To derive the *Bhujāntara* and *Carārdha* corrections find the True Sun separately, (thus):

1. Aśvattha is the author's native village of Alattūr in Central Kerala. On this see the Introduction.

क्षेप्यं ध्रुवं स्वमध्ये मण्डलशुद्धे च शशिपाते ।

एवं साध्या विहगा ग्रहणे दृक्साम्यमिच्छद्भिः ॥ ११ ॥

केचिदहितुङ्गशशिनां दृग्भेदं वर्णयन्ति, शशिनोऽन्ये ।

शशितमसोरित्येके, पक्षोऽयं सम्मतोऽधुनाऽऽप्ताकम् ॥ १२ ॥

[देशान्तरसंस्कारः]

देशान्तरसंस्कारः कार्यः स्यान्मध्यमे; तमथ वक्ष्ये ।

गतिलिप्ता देशान्तरयोजनगुणिताः स्वभूमिवृत्तहताः ॥ १३ ॥

लिप्तास्ताः प्रक्षेप्या रेखायाः पश्चिमे, विशोऽध्याः प्राक् ।

अश्वत्थाख्याद् ग्रामादष्टादशयोजने किल प्राच्याम् ॥ १४ ॥

3240

समरेखा, ऽत्र तु भूमेर्वृत्तं शून्याधिपमलगुणतुल्यम् ।

2-18

अत्र तु पलभा पठिता दुष्टा-स्त्री-त्यक्षरैर्वृधैः पूर्वैः ॥ १५ ॥

[मुजाफलसंस्कारः]

दोर्विवरचरदलार्थं पृथगथ दिवसाधिपं स्फुटीकुर्यात् ।

11. ^{a)} A.B.E. क्षेप्यध्रुवं ^{d)} C. दृक्साम्यमिच्छद्भिः ; E. ग्रहणे तु न संशयः कार्यः.

12. E omits the *śloka*. ^{ab)} D. शशिनोर्दृग्भेदं. ^{cd)} D. reading different :

अधुना परीक्ष्य कल्पितमस्माभिः शशिन एवेति ।

14. ^{a)} A. लिप्तान्ताः ; here, °स्ताः has been struck off and °न्ताः substituted.

15. ^{b)} B. शून्याधि.

16. ^{ab)} E. दोर्विवरे चरमलत्वं (lacuna, unindicated) साधिप-gap-स्फुटीकुर्यात् ।

16b-17a. The Mean Sun reduced by its Apogee (*Mandocca*, viz. 78° , which is supposed to be known) is found. (This is called *Mandakendra*). Its Great Sine¹ multiplied by 3 and divided by 80 will be the *Bhujāphala* (Equation of the Centre) which is additive or subtractive as the *kendra* is from Libra or Aries, respectively.

17b-18a. The *Bhujāphala* of the Sun divided by 6 is (the correction) for the Sun, in seconds; for the Moon (the division is) by 27 (and the result is) in minutes. This correction to the respective Mean positions is subtractive or additive according as the Sun's *Bhujāphala* is subtractive or additive.

(Correction for Decl. Ascen. Difference)

18b-19. (Take the figures): 20, 40, 57, 72, 82 and 85 as the *vyās* for the half-signs (i.e., 15° , 30° , 45° etc.) of the *Bhujāṁśa*² of the True Sun to which the Precession of the Equinoxes has been added. These *vyās* multiplied by the length in *aṅgulas* of the Equinoctial Shadow and then divided by 4 give the *Carārdha* (Declinational Ascensional Difference) in *nādikās*.

20. The mean daily motion of the planet in minutes multiplied by the Sun's *Carārdha-vināḍis* (got as above) and divided by 3600, gives the result in minutes. These are to be applied to the Mean position (of the respective planets).

21a. The *Carārdha-vināḍis* (got as above, *śl.* 20) decreased by their one-sixtieth part form the correction in seconds for the Sun.

21b. For the Moon, these *vināḍis* multiplied by 20 and divided by 91 give the correction in minutes.

1. Great Sine or *Mahāvya* is the sine having *Trijyā* (or sine 90°) = 3438.

2. The angular distance gone in the first and third quadrants, and to go in the second and fourth quadrants is called *Bhujā* here.

स्वीयोच्चहीनभानोर्वाहुमहाज्या विभिश्च संगुणिता ॥ १६ ॥

80

खाष्टहता बाहुफलं भवति, स्वर्णं क्रमात् तुलाजाद्योः ।

6

27

भानुभुजाफलतोऽङ्गैर्विकला भानोर्; विधोः कला ऋक्षैः ॥ १७ ॥

स्वे स्वे मध्ये कुर्याद् भानुभुजाफलवशाद् ऋणं च धनम् ।

[चरार्थसंस्कारः]

20

40

57

72

82

85

अत्रे-र्नाभिः-सोमः-प्रासीद्-राजा-मूदी गृहार्धज्याः ॥ १८ ॥

सायनभानुभुजाया; एता जीवाः पलाङ्गुलैर्निहताः ।

4

विहताः पुनश्चतुर्भिर्भवन्ति ताश्चरदलविनाड्यः ॥ १९ ॥

भानोश्चरदलविघटीश्रुणा खेटस्य मध्यगतिलिप्ताः ।

3600

खाभ्रसराम-भक्ता लिप्ताः खेटस्य मध्यमे कार्याः ॥ २० ॥

चरदलविनाडिकास्ताः पण्ड्यंशोना स्वेर्विलिप्ताः स्युः ।

20

91

नखगुणितास्तु विनाड्यो विधुनवभक्ता विधोर्भवन्ति कलाः ॥ २१ ॥

17. ^{b)} स्वर्णं क्रमात् corrected by the revisor to स्वर्णं कुर्यात् . E. तुलाजाये.

^{c)} Before this A.B.C. have an additional *śloka* giving an alternate method for the calculation enunciated in 17^{cd}-18^{ab} :

भानुभुजाफलनिम्ना मध्यगतिः खाभ्रषट्कुयमभक्ताः ।

शोथ्या देया वा स्यान्मध्ये खेटस्य सूर्यदोःफलवत् ॥

with the variant, C. शोथ्या वा देया वा in c

^{d)} E. ऋण for ऋक्षैः, corrupt

18. ^{cd)} C. omits this line and the following, viz. 19^{ab}. ^{d)} A.B.D. मुदी.

20. ^{b)} B. मध्यगति br. off. A. लिप्ताः om. ^{d)} B. लिप्ताः स्युर्मध्यमे च ताः कार्याः.

22. At sunrise, the corrections (pertaining to the Precession-corrected Sun in the six signs) beginning with Aries are subtractive and (to the six signs) beginning with Libra they are additive; the reverse is the case at sunset.

In the computation of the Node, all (the corrections, *Deśāntara*, *Bhujāntara* and *Carārdha*) are reverse, (i.e., additive becomes subtractive and vice versa).

(Computation of True positions)

23. The Mean Sun and Moon, calculated in the above manner, should be converted properly into their True positions.

The Great Sine (of the Mean Moon reduced by its Apogee) multiplied by 7 and divided by 80 will be the *Bhujāphala* for the Moon.¹

24-25a. The *Bhujāphala* (Equation of the centre) of the Moon is to be especially converted into arc. The number of degrees (contained in the *Bhujāphala*) multiplied by itself and reduced by 3 are (to be considered as) minutes. When this is added to the *Bhujāphala*, the arc for the Moon is got. This (method) is not (to be applied) for Mars etc.

25b. Find the True positions of the Sun and the Moon for sunrise and sunset, on the New or Full Moon day.

(The Great Sines)

25A-B. (The 24 Great Sines from 0° to 90° at intervals of $3\frac{3}{4}^\circ$ are) :

$3\frac{3}{4}^\circ$	225 ;	$33\frac{3}{4}^\circ$	1910 ;	$63\frac{3}{4}^\circ$	3084
$7\frac{1}{2}^\circ$	449 ;	$37\frac{1}{2}^\circ$	2093 ;	$67\frac{1}{2}^\circ$	3177
$11\frac{1}{4}^\circ$	671 ;	$41\frac{3}{4}^\circ$	2267 ;	$71\frac{3}{4}^\circ$	3256
15°	890 ;	45°	2431 ;	75°	3321
$18\frac{3}{4}^\circ$	1105 ;	$48\frac{3}{4}^\circ$	2585 ;	$78\frac{3}{4}^\circ$	3372
$22\frac{1}{2}^\circ$	1315 ;	$52\frac{1}{2}^\circ$	2728 ;	$82\frac{1}{2}^\circ$	3409
$26\frac{1}{4}^\circ$	1520 ;	$56\frac{1}{4}^\circ$	2859 ;	$86\frac{1}{4}^\circ$	3431
30°	1719 ;	60°	2977 ;	90°	3438

1. The work for the Sun has been given in *sl.* 16, 17a. The omission to mention the Moon's anomaly here indicates that the author presupposes this also.

मेषादिभवाः शोऽध्याः, क्षेप्या जूकादिसंभवा उदये ।
त्रिपरीतं त्वस्तमये; व्यस्तं राहोः स्फुटे निखिलम् ॥ २२ ॥

[स्फुटक्रिया]

एवंकृतौ तु मध्यौ सम्यग् रविचन्द्रयोः स्फुटीकुर्यात् ।

⁷ सप्तम्या ⁸⁰ तु महाज्या खाग्रहता दोःफलं भवेदिन्द्रोः ॥ २३ ॥

इन्द्रोर्भुजाफलस्य तु चापीकरणं विशेषतः कार्यम् ।
दोःफलभागाः स्वग्रास्यूना विकला भवन्ति, तत्सहितम् ॥ २४ ॥

दोःफलमिन्द्रोश्चापीकृतं भवेत्, नैवमवनिजादीनाम् ।
उदये चाप्यस्तमये पर्वदिने रविविधू स्फुटीकुर्यात् ॥ २५ ॥

[महाज्याः]

²²⁵ शरारनुद् ⁴⁴⁹ धीभवतः ⁶⁷¹ कथंचनो ⁸⁹⁰ नृलीजनो ¹¹⁰⁵ मानरूपः ¹³¹⁵ सयालया ।
¹⁵²⁰ अरामया ¹⁷¹⁹ धीव्यथया ¹⁹¹⁰ नयाधिया ²⁰⁹³ बुधोन्निरुत् ²²⁶⁷ सूक्तखरः ²⁴³¹ कलाभरः ॥ २५A ॥

²⁵⁸⁵ महाशरो ²⁷²⁸ दूरसरो ²⁸⁵⁹ धमदुरो ²⁹⁷⁷ ससद्दुरो ³⁰⁸⁴ वेदनगः ³¹⁷⁷ सुसङ्कुलम् ।
³²⁵⁶ तृणोरगो ³³²¹ यन्त्रबलः ³³⁷² प्रसङ्गगीर् ³⁴⁰⁹ धनावली ³⁴³¹ कालभृगुर् ³⁴³⁸ जलेवलम् ॥ २५B ॥

22. ^{a)} C.D E. read the *pāda* differently : युक्तिवशादिप्रकाले तु.

25. ^{b)} C. मनुजादीनाम्, corrupt. ^{c)} A.B.C.D. वा for च.

25A. C.E. omit the two old well known mnemonic verses 25A and B, which, really speaking, do not belong to this text, but are quoted here for convenience.

25B. ^{a)} A.B.C.E. हसद्दुरो for ससद्दुरो. ^{c)} D. यन्त्रगलः. ^{d)} B.D. जलेविला. All Mss. add at the end : इति महाज्याः.

(Syzygy)

26. Putting down the Sun and the Moon for sunrise on the New Moon day, and the Moon and the (Sun+6 signs) for sunset on the Full Moon day, consider their conjunction.

27a. If the Sun is greater, the conjunction is yet to take place, and if the Moon is greater, it is past.

27b-28a. The difference between the Sun and the Moon, converted into minutes and again multiplied by 60 is divided by the difference of their True daily motions in minutes: the result will be the *nādikās* to or from the (moment of) conjunction.

28b. The conjunction of the (said) Sun and Moon takes place only at the moment of the Syzygies (*Parva*).

29. The True daily motion (for that day) in minutes is multiplied by the number of *nādikās* to (or from) the moment of conjunction and (the product) divided by 60, is added to the respective True positions (of the Sun and the Moon) when the conjunction is yet to take place and subtracted when the conjunction is past.

30a. This done, the Sun and the Moon will be for the end of the Syzygies and be 'of equal minutes' (i.e., equal except for the *Rāsi*-s).

(Possibility of Eclipses)

30b-31a. If the *Bhujāṁśa* of (Sun-Node) is less than 13° , an eclipse of the Moon may be expected; and, so for the Sun, if (the *Bhujāṁśa* is) less than $(11^\circ + \text{the digits of the equinoctial shadow})$ (of the place).

(Measure of the Orbs)

31b. The True daily motion of the Sun (for the day) in minutes, multiplied by 5 and divided by 9 is (the measure of) its diameter in minutes.

[पर्व]

उदयेऽभावास्यायां रविचन्द्रौ, चन्द्रपङ्कभयुतसूर्यौ ।

पूर्णयामस्तमये विन्यस्य, विचिन्तयेत् तयोर्योगम् ॥ २६ ॥

भानावधिके योगस्त्वेष्ट्यश्च, चन्द्रेऽधिके गतो भवति ।

चन्द्रार्कयोस्तु विवरं लिप्तीभूतं पुनश्च षष्टिघ्नम् ॥ २७ ॥

विभजेत् स्फुटगत्यन्तरलिप्ताभिर्योगकालघटिकाः स्युः ।

पर्वान्तकाल एव हि रविचन्द्रमसोस्तु योगः स्यात् ॥ २८ ॥

योगघटिकाभिनिध्नाः स्फुटगतिलिप्ता विभाजिताः षष्ट्या ।

एष्ये योगे देयाः, शोध्या योगे गते स्फुटे स्वे स्वे ॥ २९ ॥

एवंकृतो रवीन्द्र भवतः पर्वान्तकालजौ समकलौ च ।

[ग्रहणसंभवः]

राहूनार्कभुजांशा

विश्वोनाश्चेन्निशापतेश्चिन्त्यम् ॥ ३० ॥

ग्रहणं, ते सपलाङ्गलरुद्रोनाश्चेत् तथा सवितुः ।

[विम्बमानम्]

भानोः स्फुटभुक्तिकलाः पञ्चघ्ना नवहताः स्वविम्बकलाः ॥ ३१ ॥

28. ^{a)} B C.D. °चन्द्रमसोस्तयोस्तु.

29. ^{a)} A.B. °भिनिध्ना, hypermetrical; E. घटिकाविनिध्ना.

30. ^{b)} C.D.E. पर्वान्तजौ समकलौ च.

31. ^{d)} E. च for स्व.

32. The True daily motion of the Moon (for the day) in minutes divided by 25 is (the measure of) its diameter in minutes.

To (the measure of) the diameter of the Sun, should be added 8 seconds, and (8 seconds) should be subtracted from (the measure of) the diameter of the Moon.

33-34a. The True (daily) motion of the Moon in minutes, divided by 10 and multiplied by the Mean daily motion of the Sun and (the result) divided by half the sum of the Sun's True and Mean daily motions, with 50 seconds added (to the result) will give the True (measure of the) diameter of the Shadow.

34b-35. The *Samparka* in the Lunar eclipse is the sum of the diameters of the Moon and the Shadow. In the Solar eclipse (it is) the sum of the diameters of the Sun and the Moon. Half the sum of the respective diameters, (i.e., the sum of the semi-diameters), is called the *Semi-Samparka* in eclipses.

36. (In the Sun's eclipse) the Sun is hidden by the Moon even as a pot by another pot. (In the Moon's eclipse) the hiding of the Moon by the Shadow is like submergence in water.

(Moon's Latitude)

37-38. The Great Sine got from (Moon—Node) multiplied by 4 and divided by 51 is the Moon's Latitude. This, multiplied by its True

25

इन्दोः स्फुटगतिलिप्ताः शरयमभक्ताः स्वविम्बलिप्ताः स्युः ।

8

अष्टौ विकला देया रविविम्बे, चन्द्रविम्बतः शोध्याः ॥ ३२ ॥

10

चन्द्रस्फुटभुक्तिकला दशभक्ता भानुमध्यगतिनिवृताः ।

रविमध्यस्फुटभुक्तयोरैक्यार्थेनोद्धृता, युताश्च पुनः ॥ ३३ ॥

50

पञ्चाशद्विकलाभिः स्फुटविम्बकला भवन्ति तमसस्ताः ।

इन्दुतमोविम्बैक्यं चन्द्रग्रहणे तु सम्पर्कम् ॥ ३४ ॥

दिनभर्तुर्ग्रहणे तु द्युमणिनिशानाथविम्बयोरैक्यम् ।

तत्तद्विम्बैक्यार्थं ग्रहणे सम्पर्कदलमिति प्रोक्तम् ॥ ३५ ॥

कुम्भान्तरेण कुम्भो यथा तथा छाद्यते रविः शशिना ।

वारिप्रवेशवत् स्यात् चन्द्रस्य छादनं तमसा ॥ ३६ ॥

[चन्द्रविक्षेपः]

4

राहूनचन्द्रबाहुप्रभवमहाज्या

चतुर्भिरभिनिहता ।

51

एकेषुभिर्विभक्ता क्षेपः स्यात् स्पष्टभुक्तिनिहतं तम् ॥ ३७ ॥

32. ^{a)} A. स्फुटभुक्तिकलाः. ^{b)} C. पञ्चानवेताः for शरयमभक्ताः. ^{c)} C. अष्टा for अष्टौ.

33. E reads this *śloka* and 34^{a)} differently, except for the first *pāda* of 33 :

चन्द्रस्फुटभुक्तिकला दशभक्ता विम्बलितिकास्तमसः ।

क्षेप्या विकलाः प्रायः पञ्चाशत् स्युस्तमोविम्बे ॥

मध्यगतिभिर्भानोः स्फुटगतिभक्तं स्फुटं तमोविम्बम् ।

D. notes a stray alternate reading found in E : प्रायः पञ्चाशत् स्युः.

34. ^{a)} C. सम्पर्कः.

36. ^{a)} C. चन्द्रच्छादनं.

37. ^{b)} E. ज्याः. ^{c)} E. एकेषुभिर्विभक्तां चन्द्रस्फुटभुक्तिताडितां भूयः.

motion and divided by its Mean motion gives a more accurate (value of the) latitude according to some. The latitude in minutes resulting from (Moon—Node) in Aries etc. is north, and that resulting from the same in Libra etc. is south.

(Special work in the Solar Eclipse)

(1. Parallax in Longitude)

39a. I state now (the calculations) that have to be done specially for the Solar eclipse.

39b-40a. Using the Sun at the time of conjunction and the measures of the rising of signs for the desired place, and the time of conjunction, calculate the *Lagna* (i.e. 'the Rising point of the ecliptic in the east' or the Orient ecliptic point) at the moment of conjunction.

40b. The Orient ecliptic reduced by 3° , (i.e. 90°), is called *Dṛk-kṣepa-lagna* (Nonagesimal).

41. The degrees intervening between the *Dṛk-kṣepa-lagna* and the Sun at that moment divided by 6 are the exact *Lambana-nata-nāḍikās*. (lit. 'Nāḍikās from nonagesimal for parallax in longitude').

42. If the *Lambana-nata-nāḍikās* are more than 15, then these subtracted from 30 should be taken as the *Lambana-nata-nāḍikās*.

मध्यगतिभक्तमिन्दोर्विक्षेपं स्फुटतरं वदन्त्यन्ये ।
क्षेपकला मेघादौ जाताः सौम्यास्, तुलादिजा याम्याः ॥ ३८ ॥

[रविग्रहणे विशेषः—१. लम्बनम्]

सूर्यस्यैव ग्रहणे कर्तव्यं कर्म यत्तदथ वक्ष्ये ।
पर्वान्तोद्भवविणा स्वदेशमानैश्च योगनाडीभिः ॥ ३९ ॥

पर्वान्तकालजातं प्राग्लग्नं त्वानयेद् युक्त्या ।
राशित्रयहीनोदयलग्नं दृक्क्षेपलग्नमिति कथितम् ॥ ४० ॥

दृक्क्षेपलग्नभान्वोस्तत्कालजयोस्तथान्तरे जाताः ।

अंशः ⁶ षड्भिर्भक्ता लम्बननतनाडिकाः सुसूक्ष्माः स्युः ॥ ४१ ॥

अधिकाः ¹⁵ पञ्चदशभ्यो लम्बननतनाडिका भवन्ति यदा ।

³⁰ त्रिंशन्नाडीभ्यस्तास्त्यक्त्वा शिष्टास्तदा तु नतनाड्यः ॥ ४२ ॥

38. ^{ab}) E. चन्द्रस्य मध्यभुक्त्या विभजेत् सोमस्य भवति विक्षेपः.

A. bears corrections by two revisors in 37-38^{ab}, in two different hands, the revisions of both being uninked and so easily identifiable. The Ms. reads :

राहूनचन्द्रबाहुप्रभवमहाज्या (rev. ज्यां) चतुर्भिरभिनिहता (rev. ताम्) ।
एकेषुभिर्विभक्ता क्षेप्य (sic) स्यात् स्फुट (rev. स्पष्ट) भुक्तिनिहतं तम् ॥
मध्यगतिनिहत (rev. भक्त) मिन्दोर्विक्षेपं स्फुटतरं वदन्त्यन्ये ।

A revised version is written beneath these lines :

राहूनचन्द्रबाहुप्रभवमहाज्यां चतुर्भिरभिनिहताम् ।
एकेषुभिर्विभक्तां चन्द्र-gap-भुक्ताडितां भूयः ॥
चन्द्रस्य मध्यभुक्त्या विभजेत् सोमस्य भवति विक्षेपः ।

It appears that the first revisor has added what is written beneath the lines, (i.e. the second set of lines given above), and the second revisor has added the corrections made to the original lines. The second revisor, again, has added in the margin against the first set of lines : इति सुपाठः, and against the second set of lines : इति दुष्पाठः केनचित् प्रक्षिप्तः. The second revisor writes at the end of the lines : अन्य अनय-न इत्यर्थः, the significance of which is not very clear ; perhaps it might refer to the word अन्ये in the third line

40. ^a) E. पर्वकालः, corrupt. ^b) E. चानयेत् for त्वानयेत्.

41. ^b) B.C.D.E. °जयोर्विवरजाताः. °) B. अंशः षड्भिर्भक्तः.

43-44a. 25, 50, 74, 97, 120, 140, 160, 177, 193, 207, 219, 227, 234, 238, 239 : These are said to be the *Lambajyās*¹ for the (fifteen *Lambana-nata-nādikās*).

44b-45a. The *Lambajyā* of the *Lambana-nata-nādikās* divided by 60 are the *Lambana-nādikās* for the time taken. There is a correction for these.²

45b. The digits of the Equinoctial shadow multiplied by 7 and divided by 9 are the *nādikās* arising from the latitude (of the place). These are (always) south.

46. If the Equinoctial shadow is more than 3 *āṅgulas* (digits), it should be reduced by 3 and the square of the remainder divided by 45, should be subtracted from the (above) latitudinal *nādikās*.³

47. 20, 39, 56, 69, 77, 80 : These are the *jyās* for the half-signs (15°, 30°, 45° etc.) arising from the *Bhujāṁśa* of the *Dṛk-kṣepa-lagna* to which the Precession of the equinoxes has been added.

48. These divided by 20 are the *nādikās* due to *Apama*, (i.e., Declinational *nādikās*). The (*nādikās*) arising from (the Nonagesimal in) Aries etc. are north and those in Libra etc. are south.⁴

49. The difference between the *Akṣa* and *Apama nādikās* for opposite directions, and sum for the same direction is the *Dṛk-kṣepa-nata-nādikās* ; its direction should be taken as (the resulting direction of) the *nādikās*.⁵

1. This should be distinguished from the well-known *Lambajyā* or Sine Co-latitude.

2. This correction is given by *śl.* 45b-51a. It is to multiply the *Lambana-nādikās* got, by *Tribhona-lagna-saṅku* or Cos Zenith distance of the Nonagesimal.

3. What we get is the latitude of the place, given in *nādikās*, (at 6° per *nādikā*). The rule is rough, but tolerably correct for low latitudes.

4. The declination of the Nonagesimal is thus got again in *nādikās*.

5. This is the Zenith distance of the Nonagesimal, given in *nādikās*, suitable to the work. It is actually the degrees divided by 6. The author is satisfied with giving it approximately, as he feels that to be sufficient for the purpose in hand.

25 50 74 97 120 140 160
 शिखिना नमुने वसनं सुधनं नरके नवस्य नास्तिक्यम् ।
 177 193 207 219 227 234 238
 ससटो बुधकृत् सनरो धटराद् सुरराद् भगोत्र दुर्गात्रः ॥ ४३ ॥

239
 धीगिरम् इतीह प्रोक्ता नाडीनां लम्बजीवाः स्युः ।

60
 लम्बननतनाडीनां लम्बज्या व्योमषड्विभक्ताश्च ॥ ४४ ॥

तत्काललम्बनाड्यो भवन्ति. तासां भवेच्च संस्कारः ।

7 9
 स्वरहतपलाङ्गुलेभ्यो नवभिर्नाड्योऽक्षजाश्च ता याम्याः ॥ ४५ ॥

3 3
 त्र्यङ्गुलतो यद्यधिका पलभा पलभाङ्गुलं त्रिहीनं यत् ।

45
 तद्वर्गाद् शरवेदैर्लब्धाः शोध्यास्तदक्षनाडीभ्यः ॥ ४६ ॥

20 39 56 69 77 80
 अद्रौ घिग्गां तिग्गां धातौ सुस्था नन्दी गृहार्धज्याः ।

सायनदृक्क्षेपाभिधलशस्य भुजोद्भवा इमा जीवाः ॥ ४७ ॥

20
 शून्याश्विभिर्विभक्ता भवन्ति घटिकास्त्वपमजाताः ।

मेषादिभवास्ताः स्युः सौम्या, जूकादिसंभवा याम्याः ॥ ४८ ॥

अक्षापमनाडीनां विदिशां विवरं, युतिस्तु तुल्यदिशाम् ।

भवति हि दृक्क्षेपनतं; कल्प्या दिक् तस्य घटिकावत् ॥ ४९ ॥

43. ^{ab}) E. नमुने सर सुधुनं (corrupt). ^c) C. unindicated gap after ससटो to इतीह प्रो (in 44a). ^d) A. दुर्गात्र; B.C. दुर्गात्र; E. दुर्गात्रम्.

44. ^a) A. धीगरीम्; D. धीगिरिम्.

46. ^b) C. one पलभा om. by haplography. ^d) A. लब्धा.

47. ^b) C. ज्ञान्ते for धातौ. B.D.E. सुर्या. A.C.D.E. नदी, B. तुदी, emended to नन्दी to suit the metre.

49. ^c) A.C.D.E. तु for हि. ^d) C. घटिकाभिः and E. घटिका च for घटिकावत्.

50-51a. Find the *Lambajyā* (cf. śl. 43-44) of 15-minus-*Dṛk-kṣepa* (*natanādikās*) and multiply by this the *Lambana* calculated previously (cf. śl. 44-45) and divide by 239. The result will be the *True Lambana*.

51b-52a. This *Lambana* should be subtracted from or added to the *nādikās* elapsed (from sunrise) to the time of conjunction. It should be added when the Sun is less than the *Dṛk-kṣepa-lagna*, and subtracted if otherwise.

52b-53. Calculate again, as before, the *Dṛk-kṣepa-lagna* and the (True) Sun for the time of conjunction corrected for *Lambana* and find the (True) *Lambana* for that (moment). Add this (True) *Lambana* to or subtract it from the *nādikās* elapsed (from sunrise) to the time of non-corrected conjunction (as found by śl. 29-30a) (to arrive at a more correct time of conjunction).

54-55. For this (corrected) time (of conjunction) again, find Sine *Dṛk-kṣepa-lagna* and the *Lambana*. Apply this to the non-corrected time of conjunction. Repeat this (process) till the value of the *Lambana* got does not differ from that of the previous. The Mid-eclipse of the Sun will be at the (non-corrected) time of conjunction corrected by the *Lambana* (derived as above) by successive approximation.

(ii. Moon's Parallax in Latitude)

56-57a. Now, take the *nādikās* of the Zenith distance of the Non-agesimal (already) got by successive approximation during the work of (śl. 54-55), and then its corresponding Sine *Lambajyā* (given in śl. 43-44). That multiplied by the difference in degrees of the true daily motions of the Sun and the Moon, and (the product) divided by 60, will normally give the *True Nati* (Parallax in latitude) in minutes.¹

1. *Dṛk-kṣepa-nati* → *nādikā* → *Lambajyā*, since *Nuti* depends on Sine *Dṛk-nati*.

$$\frac{\text{Lambajyā} \times \text{Bhuktyantara}}{60} = \text{Natalās.}$$

Now, *Lambana* depends on *Bhukti*. Since both the Sun and the Moon have *Ehukti* in the same direction, the relative *Lambana* is proportional to *Bhuktyantara*.

The division by 60 is to reduce the *Lambajyā* which is expressed in the sine-table with a maximum of 239 (or, say, 240) to ordinary *nādikā* measure. Also, the author takes the mean relative *lambana* as 49 minutes. (Cf. Moon's mean *lambana*, viz. 53', minus Sun's mean *Lambana*, viz. 4', = 49'). The mean *bhuktyantara*, viz. 13°.2 minus 1°, being 12°.2, we have, $\frac{240 \times 12^\circ 2}{60} = 48'.8$ or nearly 49'.

$$\text{Or, } \frac{\text{Max. lambajyā} \times \text{sphuṭa-bhuktyantara}}{60} = \text{Max. natalās.}$$

$$\therefore \frac{\text{Any lambajyā} \times \text{sphuṭa-bhuktyantara}}{60} = \text{corresponding natalās.}$$

(Contd. on next page)

दृक्क्षेपनतोनानां पञ्चदशानां तु घटिकानाम् ।
आनीय लम्बजीवां प्राक्सिद्धं लम्बनं तया गुणयेत् ॥ ५० ॥

239

विभजेन् नववह्नियमैस्तत्राप्तं लम्बनं स्फुटं भवति ।
पर्वान्तद्युगतघटीष्वृणं धनं वाथ लम्बनं कार्यम् ॥ ५१ ॥

दृक्क्षेपलग्नतोऽर्के तूने धनम्, ऋणमतोऽन्यथा कुर्यात् ।
कृतलम्बनपर्वान्तद्युगते दृक्क्षेपलग्नमपि भानुम् ॥ ५२ ॥

आनीय पुनः प्राग्वत् स्फुटलम्बनमानयेच्च तल्लम्बम् ।
स्वर्णं कुर्यात् केवलपर्वान्तद्युगतनाडिकासु पुनः ॥ ५३ ॥

तद्युगतेऽपि दिनेशं दृक्क्षेपलग्नमपि च लम्बं च ।
आनीय तदपि लम्बं केवलपर्वान्तदिनगते कुर्यात् ॥ ५४ ॥

भूयोऽप्येवं कुर्यात् सिद्धयत्यविशेषलम्बनं यावत् ।
अविशेषलम्बसंस्कृतपर्वान्तेऽर्कस्य मध्यमग्रासः ॥ ५५ ॥

[२. इन्दोः स्फुटविक्षेपः]

अथ यद् दृक्क्षेपनतं त्वविशिष्टं भवति तस्य घटिकानाम् ।
गृहीयाल्लम्बज्यां, गुणितास्ताश्चण्डभानुशीतांश्वोः ॥ ५६ ॥

स्फुटभुक्त्यन्तरभागैः, षष्ठिहृता नतिकलाः स्फुटाः प्रायः ।

54. ^{b)} D.E. Extra hypermetrical वि after दृक्क्षेप.

55. ^{b)} C. Unindicated om. of यावत् to त्वविशिष्टं in 56b

56. ^{a)} B. अथ यद् दृक्क्षेप broken off ; E यद् om. ^{c)} A C.D.E. लम्बज्या.

The word *prāyaḥ* is used to indicate that the present formula envisages only the usual case when both the Sun and the Moon are on the same side of the zenith. In the exceptional case where the two are on opposite sides of the zenith, the *sum* of the daily motions (*sphuṭa-bhuktiyoga*) should be used instead of the difference (*sphuṭa-bhuktyantara*). *Prāyaḥ* may also mean 'approximately', since the *nādikās* themselves are approximate.

57b-58. Calculate as specified before (śl. 37-38) the latitude of the Moon at that moment (and apply to it the parallax in latitude (śl. 56-57a) in the following manner :) Sum of the parallax and the latitude (if both are) in the same direction and difference (when they are) in opposite directions, (the direction being that of the greater). The result obtained will be the more accurate (or corrected) latitude of the Moon (which should be used) for computing the Sun's eclipse.

(Half-duration of the Solar eclipse)

59-60a. From the square of half the sum of the diameters of the Sun and the Moon subtract the square of the corrected latitude. Find the root of the remainder. Multiply it by 60 and divide the result by the difference between the true daily motions of the Sun and the Moon. The result will be the *nāḍikās* of the half-duration of the eclipse. This is the usual method of finding the half-duration of eclipses.

60b-61a. Subtract from or add to the time of conjunction corrected for parallax in longitude the half-duration of the eclipse, and find, respectively, the times of the first contact and the last contact.

61b-62a. Calculate for these (two) particular moments the Nonagesimal, the Sun and the Moon. Using the values, (there being no need for *aviśeṣa* or successive approximation), obtained, calculate, once for all, the true parallax in longitude and the more accurate latitude, as before (śl. 56-58).

62b-64. From the square of half the sum of the diameters subtract the square of the latitude (got as above, for the chosen time, of first or last contact). Add the result to the square of the difference between the latitudes at mid-eclipse and at the chosen time, if (the two latitudes are) in the same direction; and (the square of) their sum, if in opposite directions. Find the root (of the result). The (above) root multiplied by 60 and divided by the difference in minutes between the (true) daily motions (of the Sun and the Moon) will give (the time of) half-duration (of the eclipse, in *nāḍikās*). The half duration should always be calculated in this manner.

65. Take the *Lambana* (in *nāḍikās*) for the chosen time, (*viz.* the first or the last contact), and that for the mid-eclipse. Find their difference if both are positive or both are negative. This added to the half-duration will be the True (half-duration) in the case of the Sun's eclipse.

तत्कालजहिमरश्मेरपि विक्षेपं पुरोदितं कुर्यात् ॥ ५७ ॥

समदिङ्मतिविक्षिप्त्योः संयोगो, भिन्नदिक्कयोर्विवरम् ।

स्फुटतरविक्षेपः स्यात् सूर्यग्रहणे तु चन्द्रमसः ॥ ५८ ॥

[रविग्रहणे स्थित्यर्थम्]

सम्पर्कार्धस्य कृतेर्विक्षेपकृतिं विशोध्य, शिष्टस्य ।

60

मूलं षष्ठ्या निहतं विभजेत् स्फुटभुक्तिविवरलिप्ताभिः ॥ ५९ ॥

लब्धाः स्थितिदलनाड्यः, स्थित्यर्धे प्रायशो विधिरयं स्यात् ।

कृतलम्बनपर्वान्तद्युगते स्थित्यर्धमृणधनं कृत्वा ॥ ६० ॥

स्पर्शद्युगतं तद्वन्मोक्षद्युगतं च साधयेत् क्रमशः ।

दृक्क्षेपलग्नमर्कं तत्तद्युगते विधुं समानीय ॥ ६१ ॥

स्फुटलम्बनं स्फुटतरं विक्षेपं चानयेत् सकृत् प्राग्वत् ।

सम्पर्कार्धस्य कृतेरिष्टक्षेपस्य वर्गमपनीय ॥ ६२ ॥

शिष्टे मध्येष्टजयोर्विक्षिप्त्योः समदिशोस्तु विवरस्य ।

वर्गं, विदिशोस्तु तयोर्योगस्य कृतिं पुनर्विनिक्षिप्य ॥ ६३ ॥

60

मूलीकुर्यान्मूलं षष्ठिघ्नं भुक्तिविवरलिप्ताभिः ।

विहृतं स्थित्यर्धं स्याद्; एवं कार्यं स्थितेर्दलं हि सदा ॥ ६४ ॥

तत्कालजमध्यजयोर्लम्बनयोः समधनर्णयोर्विवरम् ।

यत् स्यात् तत्संयुक्तं स्थित्यर्धं स्यात् स्फुटं रवेर्ग्रहणे ॥ ६५ ॥

58. ^a) C. विक्षेप्त्योः.

66. When, however, one of the two *Lambanas* is negative and the other positive, the half-duration added to the sum of the two *Lambanas* will be the True (half-duration).

67-68a. To the time of conjunction corrected for parallax add or subtract, as directed above, the two (True) half-durations. Find again the *Lambanas* and, (using them), the (True) half-durations. Do this again till the respective half-durations become non-differing (from their respective previous results).

68b. These non-differing half-durations are the True half-durations pertaining to the first and last contacts, (from which the times of contact are to be found).

(Half-duration in the Moon's eclipse)

69. Calculate for the Moon the two half-durations in the same manner as above, but without the calculation for parallax. Herein, the True latitude is only that derived from (Moon—node) (cf. *śl.* 37-38).

70. The half-duration calculated using the moment of first contact and that calculated using the moment of last contact are respectively subtracted from or added to the time of conjunction. The (resulting) moments will be the (True) *nāḍikās* of first and last contacts.

71a. The Mid-eclipse of the Moon is at the moment of the uncorrected time of conjunction. (cf. 28b-30a).

(Occurrence of an eclipse)

71b. When the latitude (at the moment of mid-eclipse) is greater than half the sum of the diameters, there will be no eclipse; otherwise, there will be one.

72. When the latitude is less than half (the diameter of) the eclipsing body minus (that of) the eclipsed body, there will be a total eclipse; if it is greater, the eclipse will not be total (but will only be partial).

लम्बनयो ऋणमेकं धनमन्यद् यत्र संभवति ।
लम्बनयोगेन युतं स्थित्यर्थं स्यात् स्फुटं तत्र ॥ ६६ ॥

कृतलम्बनपर्वान्तद्युगते तत्स्थितिदलद्वयं भूयः ।
प्राग्वत् स्वर्णं कृत्वा कुर्याद्लम्बं स्थितिदले च ॥ ६७ ॥

भूयोऽप्येवं कुर्यादविशिष्टं स्थितिदले तु यावत् स्तः ।
अविशिष्टे स्थित्यर्थं स्पष्टतरे स्पर्शमोक्षजे भवतः ॥ ६८ ॥

[इन्दुग्रहणे स्थित्यर्थम्]

इन्दोश्चैवं कुर्यात् स्थित्यर्थं, किन्तु लम्बकर्म विना ।
तत्र स्फुटविक्षेपो राहुविहीनेन्दुवाहुभव एव ॥ ६९ ॥

स्पर्शभवं स्थित्यर्थं मोक्षभवं च क्रमादणं च धनम् ।
मध्यद्युगते कुर्यात्; ते द्युगते स्पर्शमोक्षजे भवतः ॥ ७० ॥

केवलपर्वान्ते स्यान्मध्यद्युगतं तु चन्द्रमसः ।

[ग्रहणसंभवः]

सम्पर्कादधिके क्षेपे न ग्रहणम्, अन्यथा हि भवेत् ॥ ७१ ॥

ग्राह्योनस्य ग्राहकविम्बस्यार्धाद् यदालोकः क्षेपः ।
भवति समस्तग्रहणं तदा, अधिकश्चेन् न सकलस्य ॥ ७२ ॥

67. ^{b)} B.D. दलं for दलद्वयं. ^{c)} A. कृत्वा for कुर्यात्.

68. ^{b)} Hapl. om. after स्थित्यर्थे to स्थित्यर्थे in the next line, 69c. ^{d)} A.C. स्फुटतरे for स्पष्टतरे.

69. ^{c)} E. अत्र for तत्र. ^{d)} C. om. एव.

70. ^{d)} A.B.D. तद्युक्ते and E. तद्युगते for ते द्युगते.

72. ^{ab)} A. विम्बादूनो यदा क्षेपः.

(Graphical representation of eclipses)

73a. I am stating (next) the *Valanas* (Deviations or changes in direction) pertaining to the different moments for drawing the diagram of eclipses.

(i. Latitudinal Deviation)

73b. The *Palāṅgulas* (Equinoctial shadow in terms of digits) multiplied by *Nata* (Hour angle) and divided by 12 give the minutes of the *Ākṣavalana* (Deviation due to Latitude).

74. In the case of the Moon these are northwards when the first contact is in the forenoon, and southwards in the afternoon. For the Sun, the opposite is the case. For both (the Moon and the Sun) the direction of the deviation for the last contact is the opposite (of their respective direction for the first contact).

(ii. Deviation due to the N or S course of the Moon)

75-76a. 1, 3, and 6 are the Sines *Āyana-Valana* (Deviation pertaining to the northward and southward courses of the Moon) in minutes for the *Koti-rāśi*¹ of the Moon corrected for Precession. The direction of deviation is the same as that of the *ayana* for first contact in the case of the Moon. It is the opposite for the Sun. For both (the Sun and the Moon) (the direction) at the last contact will be opposite to that at their first contacts.

(iii. Deviation due to Celestial latitude)

76b-77a. For the Moon the Deviation due to Celestial latitude is given by the latitude (in minutes) multiplied by 2 and divided by 7. Its direction will be opposite to that of the latitude, both for first and last contacts.

77b-78a. For the Sun, the Deviation due to Celestial latitude is given by the latitude in minutes divided by 2. Its direction will be that of the latitude, both for first and last contacts.

1. In the odd quadrants, the degrees etc. of the *rāśi* required to complete the quadrant is called *Koṭi*, and in the even, those gone is *Koṭi*.

[ग्रहणपरिलेखनम्]

परिलेखनाय वक्ष्ये तत्तत्कालोद्भवानि चलनानि ।

[१. आक्षवलनम्]

12

नतहतपलाङ्गुलेभ्यो द्वादशभिस्त्वक्षवलनलिप्ताः स्युः ॥ ७३ ॥

प्राज्ञे स्पर्शे सौम्याः सायं याम्या विधो, रवेर्व्यस्तम् ।

स्पर्शविपरीतमुभयोर्मोक्षे चलनस्य दिग् भवति ॥ ७४ ॥

[२. आयनवलनम्]

1 3 6

एकोऽग्नयो रसाः स्युः सायनविधुकोटिराशिज्याः ।

आयनवलनकलास्ता, दिक् तासामयनवद् विधोः स्पर्शे ॥ ७५ ॥

व्यस्तं भानोर्; उभयोर्मोक्षे स्यात् स्पर्शविपरीतम् ।

[३. विक्षेपवलनम्]

2 7

द्विघ्नः सप्तविभक्तो विक्षेपः क्षेपजं चलनमिन्दोः ॥ ७६ ॥

विक्षेपाद् व्यस्त स्यात् स्पर्शे मोक्षे च दिक् तस्य ।

2

द्वाभ्यां भक्तः क्षेपः सूर्यस्य क्षेपजं तु चलनं स्यात् ॥ ७७ ॥

विक्षेपवच्च दिक् स्यात् स्पर्शे मोक्षे तथा तस्य ।

75. ^{b)} C. राशिकोटिज्याः.76. ^{b)} C.D. विपरीतः.78. ^{a)} C. Haplographical omission of विक्षेपवच्च दिक् स्यात्.

(iv. Total Deviation)

78b-80a. The Celestial-latitudinal, Equinoctial and Terrestrial-latitudinal deviations are to be multiplied individually by (the actual diameter of) the eclipsed body and divided by 32. The sum of the (three results) if the (three) are in the same direction and difference if in different directions, will give the True (Total) Deviation.

When this (Total Deviation) is more than half the diameter of the eclipsed body, it should be subtracted from the diameter of the eclipsed body and the remainder taken as the True Deviation; in this case, however, east and west should be interchanged.

(The Eclipse-diagram)

80b. For the graphical representation (of the eclipse) the minutes of the diameters, deviations etc. should all be taken as so many digits (*angulas*).

81. First, draw the orb of the eclipsed body using a string of length equal to half its diameter. Across the circle draw the East-West and North-South lines.

82a. Measure off the (Total) Deviation (pertaining to the first and last contacts) in the East-West line from the east and west sides (as directed below).

82b-83a. The deviation for the first contact (should be measured off) from the east side for the Moon, and for the Sun, from the west side. The deviation for the last contact (should be measured off) from the west (side) for the Moon, and for the Sun from the east (side).

83b. Southward deviation should be measured off southwards and northward (deviation) northwards, in the same manner as sines are measured off, (*viz.*, perpendicular to the East-West line), on the circumference.

84. At the intersections of the circumference and the respective (Total) Deviations (for the first and last contacts), mark the two points representing the first and last contacts. At these points occur the first and last contacts of the eclipsed body.

[४. स्फुटवलनम्]

क्षेपायनाक्षजानां वलनानां ग्राह्यविम्बनिहतानाम् ॥ ७८ ॥

32

दन्तहतानां योगस्तुल्यदिशामन्तरं विदिकानाम् ।

स्फुटवलनं स्याद्, अधिके ग्राह्यार्धाद् ग्राह्यतो विशोध्यं तत् ॥ ७९ ॥

शिष्टं स्फुटवलनं स्याद्, व्यत्यासश्चात्र पूर्वपश्चिमयोः ।

[ग्रहणपरिलेखः]

विम्बवलनादिलिप्ताः सर्वाः कल्प्याः स्युरङ्गुलानीति ॥ ८० ॥

ग्राह्यस्य विम्बमादौ विलिखेद् विम्बार्धमानसूत्रेण ।

पूर्वापरगां रेखां याम्योत्तरगां लिखेत् तस्मिन् ॥ ८१ ॥

पूर्वापररेखायाः पूर्वापरभागतो नयेद् वलनम् ।

चन्द्रस्य पूर्वभागात् स्पर्शिकवलनं, रवेस्तु पश्चिमतः ॥ ८२ ॥

मोक्षजवलनं पश्चाच्चन्द्रमसः, पूर्वभागतो भानोः ।

दक्षिणवलनं याम्ये, सौम्ये सौम्यं च गुणकवत् परिधौ ॥ ८३ ॥

तद्वलनपरिधियोगे विन्दू द्वौ स्पर्शमोक्षजौ कुर्यात् ।

विन्दुस्थितप्रदेशे विम्बस्य स्पर्शमोक्षकौ भवतः ॥ ८४ ॥

78c-80b. C.D.E. read :

क्षेपायनाक्षजानां वलनानां संयुतिस्तुल्यदिशाम् ।

नानादिक्त्वे तेषां विश्लेषः स्फुटतरं भवेद्वलनम् ॥

C. has one more śloka :

अधिकं षोडशतो यद्वलनं द्वात्रिंशतस्तु तच्छोध्यम् ।

शिष्टं वलनं विधात् पूर्वापरभाजकौ तदा व्यस्तम् ॥

81. ^{a)} A.B.D. तथा विलिखत् तस्मिन्, E. तथा लिखत् तांस्मन् for लिखेत् तस्मिन् ।82. ^{a)} E. रेखायां.83. ^{a)} A. वलनाद्.84. ^{b)} C. स्पर्श to स्पर्श in the next line duplicated.

85-86a. Take the mid-points on the circumference of the arcs formed by the points (of the first and last contacts) as the south and north points. On the line passing through these (two points) mark off from the centre the (celestial) latitude at mid-eclipse, in the direction of the latitude in the case of the Solar eclipse and in the opposite direction in the Lunar eclipse.

86b-87. Taking the tip of this latitude-line as the centre describe the eclipsing orb using (a string) measuring half the diameter of the eclipsing body. The eclipsing body will hide that portion of the eclipsed body which lies within this circle and not which is outside it.

(Eclipse at any moment)

88a. Again, with half the sum of the diameters describe a circle so that the eclipsed body is at its middle.¹

88b-89. From the centre draw two lines passing through the points of the first and last contacts and extending up to the (outer) circle. Mark on the circumference the two points at the ends of these two lines. Call these *Ādya* (the 'First') and *Antya* (the 'Last'); *Madhya* (the 'Middle') will be the point at the tip of the latitude at mid-eclipse.

90. Construct the arc of the circle passing through the (above-mentioned) three points. That (arc) will represent the path of the eclipsing planet, since the planet moves along that circle.

91. From the square of the sum of the semi-diameters subtract (separately) the squares of the latitudes at the first and last contacts; the roots of the remainders will, respectively, be the Bases pertaining to the first and last contacts.

1. Though the author intends this to be drawn on the figure already drawn, it may be drawn separately to avoid confusion, taking care to mark the points of first and last contacts and the point of latitude at central eclipse on the eclipsed body. Or, a different colour may be used on the same figure.

तद्विन्दोर्मध्यगतौ परिधेर्भागौ तु सौम्ययाम्यदिशौ ।
कृत्वा तद्वतसूत्रे केन्द्रान्मध्योद्धवं नयेत् क्षेपम् ॥ ८५ ॥

क्षेपदिगनुसारेण द्युमणेर्ग्रहर्ण, विधोस्तु विपरीतम् ।
विक्षेपाग्रं मध्यं कृत्वा, ५थ ग्राहकार्धमानेन ॥ ८६ ॥

ग्राहकविम्बं विलिखेत्, तद्विम्बान्तर्गतस्तु यो भागः ।
ग्राह्यस्य तं हि भागं छादयति ग्राहको, न बाह्यगतम् ॥ ८७ ॥

[इष्टप्रासः]

सम्पर्कार्धेन पुनस्तद्वृत्तं ग्राह्यगर्भमपि विलिखेत् ।
केन्द्रात्तद्वृत्तान्तं सूत्रयुगं स्पर्शमोक्षविन्दुगतम् ॥ ८८ ॥

नीत्वा, तत्सूत्राग्रद्वये लिखेत् परिधिगतौ च विन्दू द्वौ ।
आद्यान्त्याख्यौ, मध्यक्षेपाग्रे मध्यविन्दुरपि कथितः ॥ ८९ ॥

खण्डं वृत्तस्य लिखेत् तद्विन्दुत्रितयं च, तद्वर्त्म ।
छादकखेटस्य भवेत्, तस्मिन् वृत्ते यतः स चरति खगः ॥ ९० ॥

सम्पर्कार्धस्य कृतेः संशोध्य स्पर्शमोक्षकालजयोः ।
विक्षेपयोस्तु वर्गं शिष्टपदे स्पर्शमोक्षवाह स्तः ॥ ९१ ॥

85. ^{b)} A.B.C.D. याम्यसौम्य°.

86. ^{cd)} A. मध्यात् कृत्वा and C मध्यं कृत्वा तु for मध्यं कृत्वाथ.

88-94. Absent in D.E. which represent the 89-*śloka* version of this work.

88. ^{a)} C. सूत्रयुगं left out.

90. ^{b)} C. corrupt : विन्दुत्रितयं च तद्वत् ।

92. The difference between the (time of) mid-eclipse and the chosen time, multiplied by the respective bases and divided by the respective half-durations, is termed, here, as the *Iṣṭa-bāhu* (Base pertaining to the chosen moment).

93. The root of the sum of the squares of the *Iṣṭa-bāhu* and of the Moon's latitude at the chosen time is (called) the *Iṣṭa-śalākā* (the distance between the centres of the bodies at the chosen moment). It should be measured off from the centre in the direction got for the time.¹

94. Describe the orb of the eclipsed body with its centre at the point of intersection of the path got (of the eclipser) and the *Iṣṭa-śalākā*. The eclipsed portion at the desired time of the Sun or the Moon, (as the case may be), will be seen (demarcated) in that (orb).

(Eclipses not to be indicated)

95. An eclipse of the Sun if less than the eighth part (of its diameter) (will not be visible) due to its brilliance (and hence) is not to be indicated. Similarly, for the Moon (an eclipse) less than a sixteenth part (of its diameter) (will not be distinguishable) on account of its great brightness (and hence) not to be indicated.

(Conclusion)

96. Thus has been enunciated the computation of eclipses according to principles derived from the ancient texts. The times (of contact etc.) as obtained from this (calculation) may, at times, differ slightly (from observation).

97. "Predictions of the effects (of eclipses) occurring (a little) earlier or later than the times due are given (by me) on the authority of ancient texts on the subject"—so says Varāhamihira in his (*Bṛhat-*) *Saṃhitā* in the section entitled 'Prediction of effects of eclipses'.²

1. The Base and the Moon's latitude will decide this direction if the *śalākā* is also derived geometrically, drawn on the figure itself.

2. The *Bṛhat-Saṃhitā* verse referred to is this:

हीनातिरिक्तकाले फलमुक्तं पूर्वशास्त्रदृष्टत्वात् ।

स्फुटगणितविदः कालः कथंचिदपि नान्यथा भवति ॥ V. 25

The idea is this: Varāhamihira thinks that eclipses must occur at the times computed by the methods in vogue at his time, and that they cannot occur earlier or later. But he has given predictions as effects of eclipses occurring earlier or later than the times as computed because the ancient Śāstras mentioned such things, not because such things could happen. Cf., in this connection, his similar statement in his

(Contd. on next page)

मध्येष्टकालविवरात् तत्तद्वाह्यं हताच्च यल्लब्धम् ।
तत्तत्स्थित्यर्थेन, प्रोक्तमिह तदिष्टबाहुरिति ॥ ९२ ॥

इष्टाख्यबाहुवर्गात् तत्कालक्षेपवर्गसंयुक्तात् ।
पदमिष्टशलाका स्याद्, अभीष्टदिशि केन्द्रतोऽथ सा नेया ॥ ९३ ॥

छादकविम्बं विलिखेद् वर्त्म-शलाकाग्रयोर्युतौ केन्द्रम् ।
कृत्वेष्टकालजातो ग्रासोऽर्केन्द्रोः प्रदृश्यते तत्र ॥ ९४ ॥

[अनादेशग्रहणम्]

[†]
स्वाष्टमभागादूनं ग्रहणं तैक्षण्याद् रवेरनादेश्यम् ।
^{††}
षोडशभागादूनं स्वच्छतमत्वात् तथा शशिनः ॥ ९५ ॥

[उपसंहारः]

इति पूर्वशास्त्रयुक्त्या सिद्धमिदं ग्रहणकर्म निर्दिष्टम् ।
कालोऽनेन च सिद्धः कदाचिदिह भिद्यते स्वल्पम् ॥ ९६ ॥

“ऊनातिरिक्तकाले फलमुक्तं पूर्वशास्त्रदृष्टत्वात्” ।
इति गदितं ग्रहणफले वराहमिहिरेण संहितायां च ॥ ९७ ॥

94. ^{b)} A.B.D. वर्ग for वर्त्म.

96-99. Absent in D.E. which represent the 89-*śloka* version of the work.

97. ^{a)} B. ऊनातिरेककाले. ^{b)} A. सर्व for पूर्व.

पूर्वशास्त्रानुरोधेन मया वज्रादयः कृताः ।

चतुर्थे भवने सूर्यात् शसितौ भवतः कथम् ॥ XII. 6

Parameśvara's view is that Varāhamihira is wrong when he accuses implicitly the ancients. He thinks that eclipses can occur earlier or later than the times computed, owing to factors not taken into account or not known, but he is sure that they are correctly computable. And, he expects astronomers to find out these factors and institute necessary corrections (*samśkāra*).

98. This being the case, it is to be postulated by learned astronomers well versed in (astronomical) theory that in the computation of the eclipses of the Sun and the Moon a correction not stated in old texts must exist.

99. Such a correction has to be postulated by astronomers after observing a large number of eclipses and with due consideration to the principles of spherics, or in the light of instructions of masters (who would have arrived at such a correction in a similar manner).¹

100. It is not possible to measure off (accurately) on its orb, the eclipsed part of the Sun, on account of its brilliance. Hence find (the extent of) that portion from circles of sunlight falling (on the floor etc.) in residences.

101. When it is not possible to measure off (accurately) on its orb even the (shadowed) dark portion of the crescent Moon, how then will it be possible on the Sun's orb, bright with countless dazzling rays.²

102. May this *Ornament of Eclipses*, composed in a hundred *āryā* (verses) by the twice-born named Parameśvara, endure for long in the minds of astronomers.

Thus ends the Ornament of Eclipses composed

by Parameśvara

1. Perhaps the author has at the back of his mind Muñjala's *Laghumānasa Gaṇita*, on which he himself has commented and which gives the correction to the Moon, known as 'Evection' and envisages the possibility of others.

2. The author's comparison is aptly chosen, for the illuminated part gives the impression of a greater diameter for the Moon, causing the well-known illusion of the old moon in the arms of the new.

शास्त्रादलब्ध एकः संस्कारो ग्रहणकर्मणि रवीन्द्रोः ।

अस्त्येवेति च कल्प्यः गणकवरैर्युक्तिविद्धिरतः ॥ ९८ ॥

दृष्ट्वा बहूपरागान् सञ्चिन्त्य च गोलयुक्तिमिह गणकैः ।

कल्प्यः स तु संस्कारस्तस्मादथवा गुरुपदेशेन ॥ ९९ ॥

भानोर्ग्रस्तो भागस्तैक्षण्यान्मातुं न शक्यते स्वतनौ ।

वेश्मान्तःपतितातपमण्डलतश्चिन्त्यतां स भागोऽतः ॥ १०० ॥

बालेन्दोरपि भागः कृष्णो मातुं न शक्यते स्वतनौ ।

किं पुनरिनस्य विम्बे चण्डतरानेकरश्मिपरिदीप्ते ॥ १०१ ॥

परमेश्वरेण रचितं द्विजेन शतसम्मिताभिरार्याभिः ।

एतद् विलसतु सुचिरं गणकानां ग्रहणमण्डनं हृदये ॥ १०२ ॥

इति परमेश्वरविरचितं ग्रहणमण्डनं

समाप्तम्

98. b) A. ग्राहकर्मणि.

c) C. तथ्यं for कल्प्यः. d) B. युक्तिविद्धिः.

99. b) B. गणितैः for गणकैः.

100. a) A. भानोः omitted. b) B. ज्ञातुं for मातुं.

c) E. पतितान्तश्च मण्डल.

101. b) B. ज्ञातुं for मातुं.

102. a) A. Stops abruptly with परमेश्वरेण. b) B. द्विजजन! शतसम्मिताभिरार्याभिः ।

D.E., the 89-sloka version reads : नवाधिकाशीतिसम्मिताभिरार्याभिः ।

APPENDIX

(Additional Correction to the Grahaṇamaṇḍana)

47. A further correction has to be applied to (the Mean position of) the planets (as computed by the methods) enunciated in the *Grahaṇamaṇḍana* (śloka 5-8). That correction, too, I shall state (here), since that has not been specified by me there.¹

48-50a. One second should be subtracted for every 200 years, from (the Mean position of) the Sun derived according to the *Grahaṇamaṇḍana*, to get its (correct Mean position).

In the case of the Moon, however, one second should be added (to its Mean position) for every 41 years.

In the case of the Node, one second should be added to (12r—Node) for every 135 years.

From the Mean of the Higher Apsis should be subtracted one minute for every three years.

50b. With the application of this correction (the Mean positions of) the Sun and other (planets) will become accurate.

(Dṛggaṇita of Parameśvara, II. iv. 47-50).

1. This correction is to be applied, naturally, from the date of the *khaṇḍa* of this work, given in śl. 5, viz. Kāli days 16,48,157, corresponding to Kāli year 4512, Kāṭaka 17, or A. D. July 15, 1410.

अनुबन्धः

[ग्रहणमण्डनोपरिसंस्कारः]

कार्यो ग्रहेषु ग्रहणमण्डनोक्तेष्वतः परम् ।

संस्कारस्तं च वक्ष्यामि, तत्र नोक्तं यतो मया ॥

शताद्वयान्दे ग्रहणमण्डनोदितभास्करे ।

एकैका लिप्तिका शोभ्या तत्सिद्धयै; शीतगौ पुनः ॥

योज्यैका वत्सरे सैकचत्वारिंशन्मिमे कला ।

पञ्चत्रिंशद्युतशते वर्षे तुङ्गेऽशकस्तथा ॥

योज्य एको; राहुमध्ये शोध्यैकाब्दत्रये कला ।

एतत्संस्कारसंयुक्तास्तत्रार्काद्याः स्फुटाः स्मृताः ॥

परमेश्वरकृतं दृग्गणितम्,

द्वितीयो भागः, ४७-५० तमाः श्लोकाः ।

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ADDITIONAL VARIANTS : Ms. F.

The following variants to the *Grahaṇamaṇḍana* are from Ms. MC. 333-C of the Kerala University Oriental Manuscripts Library, Trivandrum. The collation sheets were received too late for the variants to be incorporated as footnotes in the body of the edition. It may be noted that this manuscript belongs to the 89-*śloka* version of the work and aligns itself to Mss. D and E, belonging to the same version, whose variants are recorded in the footnotes. However, minor individual variations from Mss. D and E rule out any immediate relationship between them and Ms. F.

Śloka

3. After the *śloka* F reads, with D. E, but with minor variations :

(Broken) – सन्तप्तानां मानसकुमुदस्य भानुविम्बमिदम् ।

(Broken) सुद्धमतरम् ॥

सूद्धमोपरागगणनं प्रदर्शित (Broken)

लघुभास्करीयविवृतावधिकारस्तत्र बुद्धिमतः ॥

Note that तत्र in the last line is the correct reading as against सूत्र in D.E.

7. b) अहि for वसु. d) रसशैलैः for यमबाणैः.

8. Reads the *śloka* as in E.

9. a) °यो धृतयो for °योऽष्टादश with E, but against it in c) भूधरदहना रुद्राः
for भूमिर्भूधरचन्द्राः

10. Variant *śloka* as in E.

11. d) ग्रहणे न तु संशयः कार्यः as in E.

16. ab) Corrupt reading resembling that in E :

दर्धिवरे चरभलादं साधिपं स्फुटीकुर्यात् ।

19. Adds after the *śloka* : चरदलविनाडिकाः ।

22. d) युक्तिवशादिष्टकाले तु, in consonance with C.D.E.

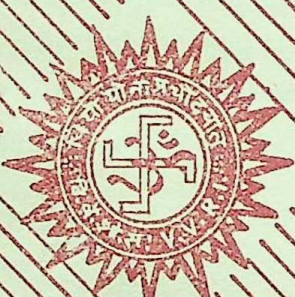
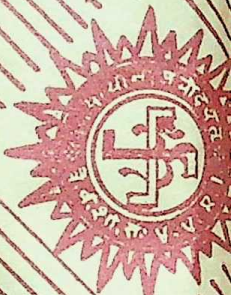
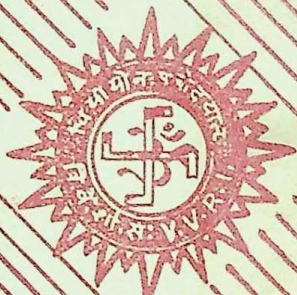
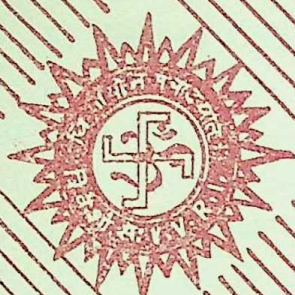
- 25 AB. Omitted. Merely reads in their place, महाज्या.

29. a) घटिकाविनिघ्ना as in E.

30. b) पर्वान्तकालजौ समकलौ च, with C.D.E.

31. d) च for स्व as in E:

- 33 and 34 *ab*) Variant *śloka* as in E.
37. *b*) निहताम्. *cd*) Variant line as in E.
38. *ab*) चन्द्रस्य मध्यभुक्त्या विभजेत् विक्षेपलितिकाः शशिनः ।
 लभ्यन्तेऽजादिभवाः सौम्या, जूरादिसंभवा याम्याः ॥
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